ARCADE-STYLE GAME DESIGN: POSTWAR PINBALL AND THE GOLDEN AGE OF COIN-OP VIDEOGAMES

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ARCADE-STYLE GAME DESIGN: POSTWAR PINBALL AND THE GOLDEN AGE OF COIN-OP VIDEOGAMES

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In memory of Eric Gary Frazer, 1984–2001.

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NOMENCLATURE

Pinball	Within this thesis the label pinball is generally reserved for those machines that have flippers (built 1947 or later). This is in deliberate contrast to how the term is typically employed in pinball literature, which usually includes pre-flipper descendants. Reasons for this delineation are outlined in Chapter 3.
Coin-op bagatelle	In lieu of referring to pre-flipper mechanical/electromechanical ball games as pinball, these plunger-only machines are referred to here as bagatelles, which historically is where this layout and gameplay style originated. In particular, the form of parlor bagatelle was adopted: arc shots, no flippers, playfield obstacles, and terminal scoring pockets.
Digital button	Although digital in modern usage often implies a microprocessor or video screen, within the scope of this thesis digital is used in its more literal and historical meanings: dealing in discrete values rather than analog/continuous, and manipulated by fingers. Buttons for flippers on pinball machines temporarily close an otherwise open circuit, which fits within this definition for digital button, even on electro-mechanical machines.
Slingshot	Powered triangular bumpers above the flippers in most pinball machines.
Backglass	Lit, painted imagery above the playfield at the rear of the machine, usually showing the game's title and scores.

SUMMARY

Several major design elements that we often take for granted in early coin-op videogames–including rule automation, real-time button play, and fiction as static theme–originated decades prior as innovations within the pinball industry. These similarities occurred on account of a number of key personnel doing leading work in both industries, convergent evolution around the business model shared by both game forms, and an irreversible trend of coin-op games becoming more differentiated and having better contextualized objectives. Although echoes of these qualities exist in more modern videogames, the relatively pure combination of these traits in early coin-op games resulted in a type of game style unfamiliar, or even off-putting, to players whose gameplay experiences are limited primarily to newer games from the past two decades. Because the coin-op gameplay formula achieved high replay value with little content, and required only minimal instruction, aspects of it have been rediscovered within the modern casual games movement and indie mobile games. Patterns from the historical relationship between pinball and coin-op videogames can serve as a lens for gaining another perspective on more recent issues and trends in the game industry, from the inherent issues with motion control to the rapid industry-changing shift toward social games.

CHAPTER 1

INTRODUCTION

The Dumbest Game

"This is the dumbest game I've ever played!" A freshman, several years younger than the pinball machine in front of him, was not getting a very good first impression.

"What's so dumb about it?" I was not looking to argue. I genuinely wondered just what about this player's experience failed to meet his expectations. Though I set the game on free play in our building's media lab, available to a range of students and faculty, by this time I had mostly heard positive responses from other grad students that were also in their mid-to-late 20's

"It's impossible. The flippers won't even get the ball up the ramps."

This complaint echoes a line from the opening for *Pinball 101*, a pinball play skills training video, when an even younger player new to pinball declares in frustration: "This game is cheating!" Apparently this type of reaction is somewhat common. The player knew what he wanted to happen, but when something else happened, he cried foul.

The pinball machine in question is a 1991 Williams *Terminator 2 (T2)*, designed by Steve Ritchie. User ratings at the Internet Pinball Database–a website popular with enthusiasts for its editorially curated archive of information on more than 5,000 pinball machines–rates *T2* as tied for #30 best solid state[1] out of more than 650 tables rated in its category ("IPDB Top 300 Rated Pinball Machines"). Professional arcade repairman Tom Grizzard finished refurbishing the machine only a few weeks prior. Lastly I, as the

[1] Solid State, abbreviated SS, means the logic is managed by microprocessor on a circuit board, rather than being purely electromechanical (pre-1975 pinball tables) or purely mechanical (early 1930's or older).

machine's owner and caretaker, went to great lengths to keep every part of the game clean and operational, each as close as possible to its original 1991 condition. This was not merely out of my obsession over details; I wanted to provide an experience consistent with Steve Ritchie's original intent. This was my first pinball machine, but not Tom Grizzard's–the flipper mechanisms were in good shape–and certainly not Steve Ritchie's, who had designed more than 10 pinball machines in the 14 years prior to *T2*.

The flippers, balls, and ramps seemed to work fine for older students and I. Of course we struggled a bit at first, too. However when we drained all three balls very quickly–as we did often early on, and still sometimes do–we just felt drawn to try again a different way. When we would time a flip poorly and lose the ball's momentum instead of working with it, or fail to maintain control over ball spin, we also occasionally watched in horror as the ball rolled back down, past the center post and straight down the drain after climbing only partway up either ramp. When this happens we do not assume that the machine is at fault.

My fellow graduate students and I are in the age group that grew up playing coin-op videogames and their Atari or NES adaptations: *Frogger*, *Galaga*, *Pac-Man*, *Donkey Kong*, *Joust*, *Defender*, *Q*Bert*, *Burgertime*, *Paperboy, Tetris,* and the like. Although the console ports were sold side-by-side with other videogames that were designed for home play, particularly by the NES era, arcade ports stood out easily on account of being much shorter, and excruciatingly more difficult. Unlike games designed for home play, like *Final Fantasy*, *Metroid,* or *Zelda*, and even unlike the later-80's coin-op videogame ports like *Double Dragon*, *Ninja Gaiden*, and *Contra*[2], these late 70's and early 80's titles had less than a few screens of distinct content. A significant fraction of the first videogames

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[2] These mid-1980's coin-op videogames and their ports, along with others like *Punch-Out!!* (1984), *Ghosts'n Goblins* (1985), and *Guerrilla War* (1987) fell into a transitional period of being both long with varied content, since for the first time in history they could be, yet still prohibitively difficult to complete.

that many of us ever played set an expectation that losing almost immediately sometimes was just part of the process, not at all out of the ordinary, nor a sign that anything was wrong. Kent says of *Defender*, "Beginning players seldom lasted more than a few seconds…" (119).

Peter Buse, in *Nintendo and Telos: Will you Ever Reach the End*, identifies this as the "death drive" described by Freud in *Beyond the Pleasure Principle* (172). As Buse connected Freud's observations to videogames, "A subject will unconsciously repeat a painful experience, not for pleasure evidently, but so as to master the experience." Belief that mastery is even possible, that practice or changing strategies will somehow affect the outcome, is part of what distinguishes this drive for mastery from pure masochism.

Perhaps the younger student frustrated by pinball did not see how anything that he could do anything differently with the flippers might produce a different outcome in the game[3]. Another classmate expressed a related misconception by asking, "Isn't it just luck whether the ball goes down the middle or not?" Many of the fundamental skills in pinball, as described in *Pinball Wizardry* and *Pinball 101*, revolve around maintaining control of the ball to minimize reliance on chance. However there's a critical difference between pinball and videogames (coin-op or otherwise) that may obscure the possibility of mastery: whereas videogames tend to make the angle and force of projectiles direct and consistent with the press of a button, whether firing shots in *Asteroids* or *Halo*, in pinball the angle and force of a each shot is controlled only indirectly, through flipper timing in relation to ball movement. Managing a pinball flipper to juggle, bring under

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[3] A "tip pass" via the nearside flipper–holding down only that flipper's button so that the ball can bounce across off its tip–usually recovers in *T2* from a ball coming back down either ramp, especially if the machine is given a light lateral bump to help shove the tip into the ball as it falls past. In cases where the return roll is farther from the middle, keeping this same position instead bounces the ball harmlessly against the base of the slingshot or rolls it up the inlane, instead of letting it roll rapidly down to the drain. This move isn't very complicated, but to players new to pinball, it may seem non-obvious that anything can be done besides simply flipping when the ball is atop either flipper.

control, then aim and fire a ball reliably at stationary targets and ramps is a non-trivial skill to learn and practice; pinball's challenge is in doing this reliably and efficiently.

This player, being born nearly a decade after me, grew up around the release of PlayStation and Nintendo 64, while coin-op arcades were on the way out[4]. Expectations of gamers in his generation were more likely set by titles that can be played for significant periods of time without losing, and moreover, that made hitting stationary targets trivial. No wonder he found this once popular game unbearable. In the language of the games he grew up with, he was being harshly berated by the game's feedback.

This exchange helped me realize just how completely different the expectations and gameplay of classic arcade-style games were than what's common in videogames known to today's college and high school students. In trying to understand his frustration, I was beginning to see that those coin-op videogames, in some ways, perhaps had more in common with pinball than they do with more modern videogames. Moreover in qualities where pinball and coin-op videogames clearly differ, considering these differences sometimes led to subtle realizations about both that I might have overlooked otherwise.

High Accessibility, High Replay Value, Low Content

In the golden age of coin-op videogames, from the 70's through the early 80's, the combination of technical limitations and then-dominant business models led to the creation of accessible, self-operating games that managed to offer high replay value from comparatively little content. The distinguishing features at the center of these designs built upon commercial game design practices and patterns of play experience found in

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[4] As Tim Arnold, the director of the *Pinball Hall of Fame* museum in Las Vegas explains in the documentary *Pinball Passion* (17:00): Americans used to stay at home for dinner and go out for entertainment, whereas around that time it became increasingly common for people to instead go out for dinner and stay home for entertainment. The flexibility of digital media enabled videogames to survive the arcade collapse by fitting into people's homes, which was not so much an option for pinball machines.

pinball machines since the late 40's. By exploring the overlap in game design between postwar pinball and early coin-op videogames, we can more easily distinguish core features that help differentiate arcade-style games in contrast to many other varieties of games: athletic competitions, board games, story-driven games, carnival games–even from home console and newer arcade machines. Further, there are echoes and adaptations of these properties ingrained deeply in many contemporary videogame designs, especially in those cases where accessible, high replay value has to be created with minimal content.

Postwar to Golden Age

Pinball machines certainly predate *World War II*. Depending on the source used and the definition of pinball applied, it sometimes begins with the competitive manufacturing boom in the early 1930's with Gottlieb's *Baffle Ball* and Raymond Maloney's *Bally Hoo* (Kent 1-3), in 1871 with the introduction of a spring plunger and playfield bells for Montague Redgrave's patented *Improvements to Bagatelle*–the one chosen by pinball historian Roger Sharpe in *Pinball!* as the first machine (21)–or even further back to the 1500's-1700's with early table adaptations of garden bowling games (Bueschel 18). Although there is a complex and fascinating history leading up to the era of pinball emphasized in this thesis, my primary aim is not to document history, but to specifically analyze the parallels and potential influences between pinball and the first generations of coin-op videogames. Readers interested in detailed historical accounts of pinball history may refer to those same sources that I am turning to throughout: Bueschel, Sharpe, Rossignoli, Shalhoub, and others listed in the bibliography.

What happened in 1947 was an event that made pinball forever after significantly closer to the experience that was later offered by coin-op videogames: based on a happy accident working on a reactive playfield element in his engineering lab, Harry Mabs invented the pinball flipper (Sharpe 55). His debut game for the flipper, *Humpty Dumpty*,

featured six going up the center, in pairs pointing outward. Prior to that point, interaction with devices otherwise recognizable as pinball machines consisted only of a plunger to arc one ball at a time toward playfield targets, with said targets mostly being terminal pockets worth some number of points or a bonus multiplier if the ball came to rest there. For the next year, most new pinball machines also had six flippers, similarly positioned until Steve Kordek used only two total at the bottom of his playfield as a cost-cutting measure[5] (Flower, Kurtz 39). Designing the lower playfield around a two flipper arrangement soon became the industry-wide standard (Flower, Kurtz 40).

Figure 1 *Humpty Dumpty*. The six flippers are along the edges. Photo by Raphael Lankar.

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[5] In another thread of pinball history that cannot be covered here in depth, there was also a legal reason for pinball designers to incorporate flippers: flippers helped distinguish these machines as games of skill, rather than games of chance. Similar machines without flippers were subject to lottery and slot machine regulations (*Pinball Passion*, Extras 37:00). In numerous major American cities, including New York City, even pinball with flippers faced restrictions or outright bans until the mid-1970's.

The introduction of flippers to pinball brought about several design features that we now often take for granted when thinking about arcade machines, but did not apply to the flipperless coin-op bagatelles that preceded them:

- The player had direct influence over on-playfield events as they occurred
- Skillful play could prolong each ball's time on the playfield
- The primary interaction became a matter of correctly timing button presses

As part of these changes, the game took on a fundamentally different character than most traditional carnival-type games. Whereas each action in a carnival game is player initiated–throwing a ball or ring at bottles, for example–for obvious reasons the player was typically not challenged to react to projectiles being thrown back. Here in pinball, with flippers, the player could be continually challenged to react. Since all action took place within the safety of the playfield glass there was no real risk from the projectile(s), and using the buttons to power the flippers gave the player a way to cause and respond to the events contained inside that separate space.

Another historical change in this domain during the late 40's and early 50's was the general fading away of many other varieties of electromechanical (EM) games that were formerly in direct competition with pinball. Pinball machines were by no means the first or only EM games to appear in arcades. Electronic fortunetellers, coin-op dioramas, shock machines, crane games, and other miscellaneous machines helped to establish the niche that pinball machines gradually took over. By the 50's however, pinball games were generally replacing other EMs for the same reason that videogames largely supplanted pinball in the late 90's: higher revenue per the floor space required. In *The First Quarter*, Kent details how Sega founder David Rosen started his business relationship to the arcade industry by repurchasing and shipping non-pinball EM games

to Japan from America (265). Such machines were available in large quantities at a discount on account of losing popularity.

On the upper end of the timeline covered, this thesis is bounded by the coin-op videogames that were created in the golden age, roughly spanning from the 1970's through the mid-1980's. Just as pinball forever changed in character by the introduction of flippers, processing breakthroughs in the late 1980's led to coin-op videogames that were far less constrained in processing power, storage of art/audio content, and representational quality. These advancements made it possible for arcade games to increasingly shift their focus toward competition over having more and higher fidelity content, and favoring more nuanced approaches to space and movement than the straightforward "mechanical" motions common to early coin-op videogames. While there are nevertheless some shared principles at work between the older and newer coin-op videogames, the game design connection between pinball and a one-on-one fighter like *Street Fighter II* or a brawler in the genre of *Double Dragon* is far more tenuous than the connection between pinball and the single-screen, low-content, predictable mechanics in games like *Asteroids* or *Space Invaders*.

Not Not-Simulation

When referencing "arcade-style," my intended meaning is the pattern of gameplay common among postwar pinball machines and coin-op videogames from their golden age. This is not to be confused with the opposite of "simulation-style," as the terms may be used in other contexts to distinguished pure play-driven design in products like *Super Mario Kart* from more accuracy-driven efforts like *Gran Turismo*.

I do not aim to make nor advance any claim here that pinball machines were the central, or at least not the only, source of inspiration for coin-op videogame designers. The entertainment industry is rich with sources of varied inspiration, and numerous smaller design elements common to both game forms–for example extra lives, high

scores, adaptive difficulty, or attract sounds–may well have been independently derived, even when years apart, rather than copied from one another. Smart designers on both sides strived to adapt their games to make the most of similar business and cultural climates. What may appear to be an act of copying 40-70 years after the fact may at the time have simply emerged as a matter of convergent evolution. The emphasis here is on the design principles and the circumstances that led to them, not to get lost in worrying over precisely what videogames borrowed from pinball versus what pinball borrowed from videogames. Pinball machines and coin-op videogames largely coexisted in the same market for decades, and even when they may have influenced one another this was not necessarily a result of deliberate imitation or adaptation.

While it may be tempting to think of the pinball as a game of the past and to think videogames as the game of the future, it's important to recognize that shifts in mainstream consumer habits, dominant business models, and countless non-gameplay logistics may have as much or more to do with the respective rises and falls than players simply finding one generally preferable over the other. However in terms of technical specs a pinball machine's resolution is the finest an eye can see, its collision sounds are far more visceral, and the level of sheer physics complexity at the core of the gameplay is at a level of fidelity still unmatched by 'physics-based gameplay' in videogames by the time of this writing in 2012.

Roadmap

In **Chapter 2, Pinball and Coin-Op Videogames** I will outline some of the existing major work that has been written by other authors, historians, and developers on either the connections between pinball and videogames, or in relation to the specific elements that I dedicate later chapters to here. Those elements in common between postwar pinball and coin-op videogames from the golden age that I will detail in this thesis are:

Machine as Operator, Play Space, and Opponent (Chapter 3): Arcade-style games, to be successful in the coin-op business, had to be self-explanatory, self-contained, and playable without another player present. In the interest of accessibility and lowering the barriers to entry for new players, these games created a play space enabling carefree interaction, in which understanding the scoring and rules might lead to higher scores but was not strictly necessary merely to play properly.

Digital Buttons for Real-Time Play (Chapter 4): Though button-based digital controls may seem trivial in hindsight, there are specific advantages and types of challenges afforded by the use of them that helped shape and differentiate arcade-style games from other traditional play experiences. Reaction-oriented play took priority over strategic decision-making, but in a form that mostly mitigated the effects of body variation, physical dexterity, or muscular and aerobic fatigue that commonly play a prominent role in real-time athletic games.

Hook-Only Fiction (Chapter 5): The story of arcade-style games, to the extent that the game's content can be framed as such, tended to have an implied beginning, gameplay cyclically realizing the moment of conflict, and no narrative resolution. Fiction was often utilized primarily as a theme, inspiring decoration and certain gameplay features, but otherwise changing only negligibly during play, or not at all.

For the **Conclusion (Chapter 6)**, I'll review the core elements in relation to one another and the circumstances that favored their creation. Additionally, I'll provide an overview of how echoes – and in some cases corruptions – of these core elements can be found in more recent videogames, typically in relation to the very same objectives that were required of arcade-style games: accessible gameplay with high replay value from comparatively little content.

When detailing particular features of the game that predate the transition to flippers, I generally aim for the earliest case that I can find. For example, electronic scoring bumpers were introduced in the mid-1930's, more than a decade before flippers,

so discussion of bumpers focuses on those earlier games. This deviation from the postwar era is intentional, to provide context for those features in relative isolation before they came together into the form now considered standard for pinball. Likewise, in cases where differences between pinball machines and coin-op videogames are most dramatic in the forms taken within more recent pinball machines–such as the significance of materiality in playfield toys–I pull in a few more recent examples. Such features still follow in a much older tradition from pinball, which I provide evidence and context for via historical cases that if shown on their own might not illustrate the differences as effectively.

CHAPTER 2

ARCADE-STYLE GAMES

> "New technologies do not simply spring out of thin air they need to be associated with familiar industries or ideas. People may have referred to the first automobiles as 'horseless buggies' as a joke, but it also helped define them… While video games are a relatively new phenomena, they benefitted from a close relationship with the well-established amusement industry." –Steven Kent, *The First Quarter* (1)

The first chapter of *The First Quarter*, Kent's book on videogame history, is dedicated to recounting the early decades of pinball. Kent focuses primarily on the major business events from the early 1930's up until the introduction of flippers circa 1950. As a journalist focused on the entertainment business, he provides a very efficient and cogent outline for how pinball firmly established a beachhead in the market space later shared (and later largely repopulated) by coin-op videogames.

What *The First Quarter* does not delve into deeply, and what interests me most as a videogame developer that grew up playing NES ports of coin-op videogames, is in what ways pinball relates to the gameplay conventions, player experience, and narrative treatments found in arcade videogames decades later. Although investigating those connections will account for the lion's share of this thesis, first we'll review what research by Kent and others can tell us about historical overlap between the pinball industry and coin-op videogame business.

Industry Overlap

When coin-op videogames began to appear in public, they did not need to start from scratch to invent their business model. Consumers were already acquainted with coin-op amusement machines from pinball and other arcade novelties. Pinball, more so than the other types of mechanical novelties such as dioramas, automaton fortunetellers,

or grip testers, offered an entertainment experience similar in challenge and format to the coin-op videogames that followed. One potential factor in that similarity is that many designers and companies were connected to both industries. What may appear on the surface to be a completely different type of game was in many ways a result of the same minds, practices, and traditions.

Prior to 1980, Williams was known primarily for their pinball games. Eugene Jarvis and Larry DeMar, both pinball programmers, then created the landmark coin-op videogame *Defender,* followed two years later by another hit, *Robotron 2084* (*Tilt*, 9:15[6]). Elsewhere within Williams in '82, John Newcomer created *Joust*. Williams created a *Joust*-themed pinball table a year later (Williams '*Joust'*).

Besides Williams, several companies now mostly associated with videogames designed and/or manufactured pinball machines first, including Midway, Sega, Data East (creators of *Burgertime*), Atari, Capcom (briefly), and Taito. Prior to Ed Boon co-creating *Mortal Kombat* at Midway, he spent years developing software for Williams pinball machines. Before Ed Boon was the voice of Scorpion in his new *Mortal Kombat* franchise, he was the voice of a dummy in a pinball machine ("Ed Boon" imdb.com; Williams '*FunHouse*').

Meanwhile, several companies now primarily known for their pinball games– including Bally, Gottlieb, and Stern–all had brief but influential forays into 80's videogames. Bally developed a failed but otherwise more technologically advanced home videogame console (Kent 101). Gottlieb created *Q*Bert*, another popular early arcade game (Davis). *Q*Bert* even included features borrowed from the company's pinball machines, such as a loud physical knocker for when Q*Bert fell off the screen (Kent 183), and a voice chip originally developed for use in pinball tables (Kent 184). At Stern

[6] Since several DVD documentaries are referenced throughout this thesis, where the time in the video or title of the relevant extras segment is available I have opted to provide that information as in-text citations.

Electronics – a company formerly making mechanical games as Chicago Coin, under new ownership by the family later known for the still-active Stern Pinball – employee Alan McNeil created *Berzerk*, another 1980's coin-op videogame hit. Only a year prior, McNeil programmed the software for the company's *Meteor* pinball game (Hunter).

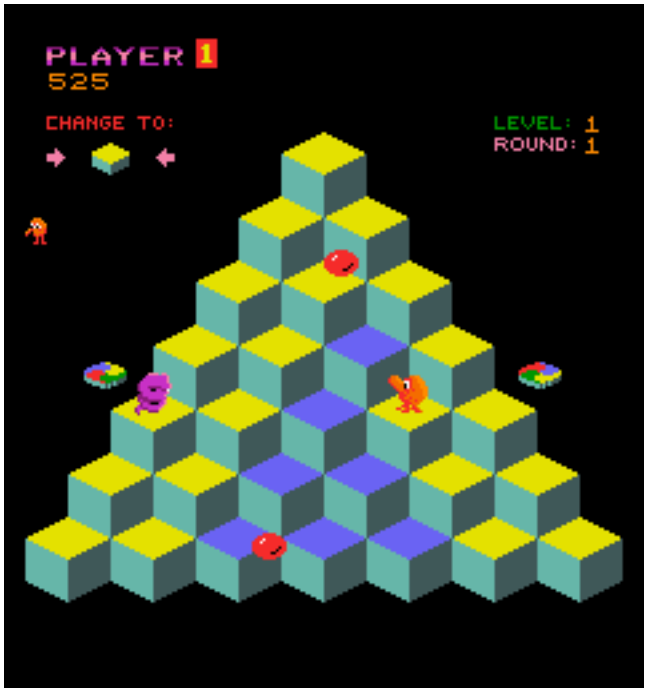

Figure 2 *Q*Bert*, made by the (primarily) pinball company Gottlieb. Screenshot from Arcade-Museum.com.

George Gomez, in addition to developing pinball machines since 1994 (Williams '*Corvette'*), worked on the original team for the *Tron* videogame, designed *Spy Hunter*, and later helped create Midway's *NBA Ballers* franchise of basketball videogames (Nardozzi). Though *Pac-Man* developer Toru Iwatani was never a pinball developer, according to Steven Kent in *The First Quarter,* "Iwatani wanted to create pinball tables, but Namco was only manufacturing videogames…" (114).

Even if these developers and companies did not deliberately model their videogame designs after the mechanics of pinball, given that in so many prominent cases the very same developers did the work to serve the very same audiences, intention may not be a necessary condition for similarity to arise in the works. It's reasonable to suspect that people immersing themselves professionally in pinball might be prone to creating similar experiences when switching to design videogames. Perhaps rollover lanes used to encourage playfield coverage in pinball partly inspired the pellets filling hallways in *Pac-Man*, or perhaps the special-when-lit pattern[7] common in pinball games help suggest the temporary scoring state change caused by power pellets. It cannot be said with certainty that these types of features trace back to pinball origins, but for Iwatani and other classic coin-op designers that were previously pinball enthusiasts or developers, the exposure and thus potential influence on practices for real-time gameplay design is clear.

Logic Maze

Michael Nitsche, in *Video Game Spaces: Image, Play, and Structure in 3D Game Worlds*, introduces the logic maze, defined as "a conditional maze that depends on changing access conditions that shape the available space." Although Nitsche introduces this concept to describe the types of navigational labyrinths in PC videogames, parlor bagatelles at least as early as *Advance* from 1933 by Harry Williams provided conditional mazes in which players were able to change access by achieving specific ball placement (Sharpe 27). Later pinball machines employed drop targets, roto targets, blocking gates, diverters, and other mechanisms to alter playfield routes and target sequences.

[7] Special-when-lit refers to the two separate concepts. Special refers specifically to an operator-determined award (free replay, extra ball, or bonus points) marked on the machine ambiguously as "Special." "When lit" refers to reward circumstances on the playfield that vary based on whether the light bulb on or near that element is on, which gets toggled based on some other accomplishment or target sequence on the field. Another common application of when lit is the use of bumper caps on older pinball tables that might read, "100 points when lit" that are worth only 10 points when not lit, toggling lit status either when struck, when a drop target bank is cleared, or when some other objective on the playfield is accomplished.

The changing navigable spaces in *Centipede* and *Tetris* provide coin-op videogame examples. In *Centipede*, mushrooms are constantly laid fresh by enemies, and cleared by player gunfire, resulting in a playfield that changes form during play. In *Tetris*, the puzzle that the player needs to fit each successive piece into is a function of previous piece placement. The space, both conceptually and literally, changes throughout play.

Figure 3 Diverters on this table affect the path of subsequent shots (Genco '*42nd Street*').

Exhilaration and Reaction

Professors Jacobs and Egert employ *Future Pinball*, a high fidelity pinball simulation program with a built-in layout editor, to introduce level design to their game history students (272). This exercise was created as an alternative to an activity from an older version of their syllabus, which had players inspecting and playing physical pinball machines. The assignment fits within the curriculum because, "[pinball] design and development provides a constrained analogue to videogames in general." Jacobs and Egert turn to pinball design as a platform enabling students to explore those aspects of

gameplay that are most strongly emphasized in real-time button-based games, and could therefore not be faithfully recreated in card, board, or sport prototypes. I identify these qualities of play as exhilaration and reaction, which certainly can exist in games of all types, but take on a particularly pure form in the fast-paced, immediate, and amplified action of pinball and coin-op videogames.

Designing for Near Misses

One side effect of gameplay progressing due to collisions in continuous space is that a missed shot is not lost, but instead how it misses can have ramifications on play. This helps maintain ball speed during the game, keeping a heightened pace and continuous strain on player reaction. It also means that the player is always scrambling and recovering, planning on one result but needing to constantly adapt to another.

In chess, a knight cannot accidentally "overshoot" being moved to its intended tile. Success in that type of game is not an issue of successfully executing the most fundamental movements, but instead comes down to the pure decisions about what fundamental movements to make. In golf, by contrast, every hit is extremely likely to deliver the ball either farther or less far than intended. When a golfer misses her intended mark, she may end up hitting their next stroke in a sand trap, from the rough, behind a tree, or otherwise in an unfavorable circumstance. The miss has continued significance to the game, beyond simply not achieving the exact shot that the player intended. When setting up shots, golfers need to weigh the relative risks associated with missing by a likely deviation in any direction. Landing the ball in water poses a particularly serious risk, for example, and so golfers are likely to err in favor of taking less optimal shots than they might otherwise in an effort to minimize the chance of that happening.

Pinball and early coin-op videogames were designed to create opportunities for misses to still have some effect. Usually, unlike these previous examples listed, a positive effect for the player. When a player in *Space Invaders* or *Galaga* fires into the crowd of

aliens, intended to hit one specific target, the shot will often miss, but connect instead with another enemy. The same effect occurs in *Centipede* and *Robotron 2084*, which involve target fields so dense with enemies that at times it may be difficult to fire without hitting something. In particular for *Missile Command*, missing the specific warhead the player shot for may yet be helpful by detonating other nearby warheads that were in the same general area.

In an interview for the documentary *Tilt*, pinball designer Pat Lawlor explained that designers go out of their way to ensure that even when the player misses or fires randomly, something good will happen (*Tilt*, extras, *"*Designing a Pinball Machine*"* 1:45). Lawlor explains that effect from the player's perspective with the phrase, "I meant to do that." As the player figuratively holds their breath for a moment to see whether their latest shot moves as expected, when it often does not, the player is still able to rationalize the different positive outcome as though it were intentional. This factor may be even more important due to the public settings in which pinball and coin-op videogames were designed to be played: even if no one else is directly paying attention, a player's performance is technically on display, and may involve feeling a bit self-conscious.

Randomizing Elements

Blatant random element in these games, which are completely or nearly independent of player skill, creates still more wiggle room to protect one's ego with excuses. To add overt elements of chance, pinball games often included backglass spinners (as with Williams '*Jive Time*'), or roulette wheels under the playfield for captive balls (appearing in Gottlieb's *Hi-Score*, from 1967, among many others). When tables became increasingly computerized these features evolved to show up on the dot-matrix display (Williams '*Terminator 2*'). In coin-op videogames, the hyperspace function in *Asteroids* or the spider movements in *Centipede* are determined by factors not revealed to the player.

Randomizing elements can have a deterministic foundation, but involve so many hidden variables that, from a practical standpoint, players cannot predict the outcome. Though these elements add to unpredictability in a game, because they are much more subtle about it they can help maintain the impression of an otherwise skill-based game while ratcheting up the role of luck. In pinball, this type of randomness takes several forms, including ball spin and the kick trajectory caused by the slingshot bumpers above each flipper. The behavior of steel balls cascading down a slanted board covered in pins is so nearly random that it's the concept behind the Galton box, which as Bulmer explains, produced a binomial distribution purely through mechanical means (183).

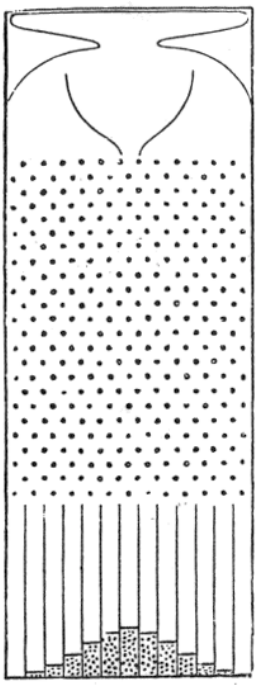

Figure 4 Galton box. Balls rolling from the top half a 50/50 chance of falling left or right at each peg, producing a binomial distribution at the bottom. Image by Francis Galton.

In coin-op videogames, non-obvious connections between numbers and events cause similar types of unpredictability. The number of steps taken or jumps made in

Bubble Bobble can influence which power-ups appear in the next stage (Tjasink, Rahme). In *Pac-Man* the ghosts employ such an indirect chase algorithm that their behaviors often appear random, even though their behaviors are highly deterministic based on Pac-Man's position (Birch).

The complex determinism underlying these sources of what newer players perceive as pure unpredictability also creates opportunity for highly dedicated players to anticipate or manipulate the odds–a bit like counting cards to gain an advantage in casino games. Skilled pinball players aim to keep the ball from being thrown from the slingshot bumpers above either flipper, since it results in unpredictable ball movements (*Pinball 101* 52:44). Advanced pinball players learn through practice when to anticipate ball spin, mitigating that as a source of unpredictability. In the same way, elite players of *Bubble Bobble* can play in particular ways to affect which power-ups appear in upcoming levels, competitive *Pac-Man* players memorize routines to exploit the AI's determinism, and experienced *Asteroids* players do not rely on hyperspace functionality to avoid danger.

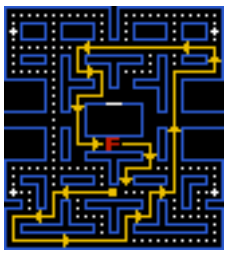

Figure 5 The first steps in *Pac-Man* patterns for levels with Strawberry or Peach items. Because the ghost AI responds to the player in deterministic ways, moving Pac-Man in a certain way causes the seemingly random ghost movements to always happen the same, too. Pattern by John Birkner.

Pavlovian Reinforcement

"This is Pavlov," pinball designer Pat Lawlor explained in an interview for *Special When Lit* (35:18). "We're teaching you that when you hear a thing in the game it

means something." A 1966 pinball game contained a clear example of this: it that featured a small animatronic monkey inside the backglass that struck a bell with a small hammer for every 100 points earned (Gottlieb "*Central Park*"). As early as 1951, a convention began in pinball of acknowledging free replay events by the loud crack of a "knocker" hammering metal together (D. Gottlieb & Co. '*Happy Go Lucky'*), a standard upheld in modern pinball games up until Stern's *Austin Powers* machine in 2001 (Steven An, personal conversation, 25 March 2012).[8]

As George Gomez explains, "Everything in the game is designed to reward [the player] the further he gets into the game, make him feel like a hero. We should be going crazy with the lights, the music should come up… all those things should be giving the feedback to the player that WOW, look what I just did." One of the many roles filled by a pinball machine is that of the cheering crowd. Achievements consistently get recognition in pinball.

Coin-op videogames similarly employed distinctive tones and celebratory musical stings to represent major events, whether the death of *Pac-Man*, or the completion of a stage in *Tempest*. While *Super Mario Bros*, *Zelda*, and *Final Fantasy* are home console examples from NES, not coin-op, made at the tail end of the golden age they honed this use of sound and music to an art. The sounds of catching a 1-Up mushroom in *Super Mario Bros*, acquiring a new item in *Zelda*, or winning a battle of *Final Fantasy* are emotionally loaded tones for an entire generation of gamers on account of the hard-earned gameplay events that coincided with hearing these sounds.

In January 1979, a pinball machine made it to market that played different music based on which gameplay mode or event the player activated (Williams '*Flash*'). This

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[8] This crack also played into pinball's integration into public settings, since it alerted others nearby of a player's successful accomplishment (*Special When Lit* 25:18). The role of the knocker sound is analogous to the achievement announcements of a modern casual game with social integration, such as Facebook postings of high scores in *Bejeweled Blitz* or Tweets indicating distances run before dying in *Canabalt*.

helped convey the seriousness or importance of situations during play. In 1980, *Pac-Man* similarly employed a special musical loop while a power pellet was active, reinforcing the visual feedback to let the player know something special and very different is happening. *Tetris* varied the tempo of its music to add excitement when running out of space. A decade later, when *Super Mario 64* changed instrumentation as Mario progressed through the environment (Kondo). In 2001 waves were made in the game audio community when *Halo* used dynamic music to recognize and call attention to gameplay pacing events (O'Donnell).

'Object-Oriented' Gameplay Elements

In the same way that the knocker came to be an audio clue indicating the player won a Free Play, the various components used in pinball tables became a clear visual language enabling players to transfer their familiarity with past games to new layouts. Although visual representations in coin-op videogames could vary widely within the constraints of their platforms, for pinball the dependence on physical forces for gameplay action and the need to engineer highly reliable parts caused function to largely dictate form. This led to similar shapes being reused across virtually all pinball games for components with similar functionality, resulting in clear conventions and a simple visual language. When electronic scoring bumpers were first added to pinball in the 30's, they did not yet hammer the ball away. However once a company figured out how to create the jet/pop bumper mechanism, nearly every other company in the business was soon duplicating their design[9]. The standardization of a bumper's shape, though dictated in

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[9] These duplicated part designs were not truly identical, but often involved innumerable minor changes in the constituent pieces and mechanisms. This was not only on account of different supplier partnerships, but also because pinball is a physical game composed primarily from collections of physical inventions, and consequently patents played a much more common and less controversial role in commercial pinball design than they have in commercial videogame development. In a recent example of the role patents continue to play in the pinball industry, when a new pinball manufacturer opened in 2011 it formed an agreement with

part by engineering constraints, became an understandable part that players could learn the operation of. The same applies to the slingshot bumpers over the flippers, to spinners, rollover wires, a kick-out holes.

Even flippers and their configuration on the board, completely absent from pinball before *Humpty Dumpty* added six of them in 1947, saw comparatively few iterations on their positioning (such as the outward-facing, center-based flippers in *Triple Action*) before largely standardizing to their modern inward-facing arrangement[10]. First and foremost, function has to drive their form, and out of the few arrangements producing similar effects, companies favored whichever approach offered the most reliable component relative to its cost to manufacture and difficulty to install.

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the company that presently controls approximately 40 patents for Williams and Bally playfield parts ("Jersey Jack Pinball & Planetary Pinball Form Parts & IP Pact").

[10] Gottlieb's *Just 21* in January 1950 was among the first games to use inward-facing flippers (Rossignoli 41). *Just 21* has a much wider drain between the flippers than a modern game, however, and was still in the era of 2-inch flippers as opposed to the 3-inch flippers used in pinball machines since 1968 (Williams "*Hayburners II*")*.*

Figure 6 Flippers on *Triple Action* from 1948. Photo by Raphael Lankar.

Having played pinball on any machine before, players can attempt a new table that has a completely different layout, and easily recognize what most parts will do in response to collision. This same transfer of conventions applied to videogames as well, both within individual games and across genres. Appearance of enemy types and colors consistently reflected differences in behavioral properties, that looked a particular way always behaved in the same way. In *Joust* for example all weak Bounder enemies are red, all medium Hunter enemies are silver, and the hardest Shadow Lord enemies are always dark blue ("Joust - Videogame by Williams Electronics, Inc. (1967-1985)"). The Asteroids in *Asteroids* were sized consistently to reflect how many more times they would break into smaller rocks when destroyed; recall that, having no real physics constraints within the software code, this decision about size was purely for the purpose of gameplay and communication, not out of necessity to preserve mass. In a number of games players were taught the convention that stationary, unanimated, floating objects were power-ups to be collected, as for example in *Bubble Bobble* or *Pac-Man*.

Masculine Culture

Although I will outline the progression and oddities about fictional themes within pinball and golden age coin-op games in Chapter 5, earlier and easier than that is the critical point that pinball shares the same gender bias now more commonly identified with videogame culture. In *Special When Lit* (24:01), Pinball Hall of Fame owner Tom Arnold explains, "…the art, it's definitely something that's pitched towards young males. There's not really a lot of female-friendly images on these. Part of the adolescent male fantasy is guns, women with large breasts, magic spells, any violent misogynist thing you want is there on pinball."

Consistent with that, when women are depicted within the game art–even on otherwise uncharged themes–they are consistently depicted in provocative pose and dress. When Kristi Engle Gallery in California opened a show in 2009 to share the backglass artwork of Dave Christensen (a graphic designer active in the early 1970's for famous tables including *Fireball*, *Old Chicago*, and *Capt. Fantastic*), they titled the exhibit, "Broads, Boobs and Buckles: The Pinball Art of Dave Christensen."

Figure 7 *Air Aces* from 1974. Art by Dave Christensen. Photo by Philippe Thibault.

Figure 8 *Humpty Dumpty* from 1947. Why are there women in bikinis on the backglass of a game themed around an old fairy tale? Because most of the players were males. Art by Roy Parker.

By comparison, the masculine bias of non-stop violent themes in coin-op arcade games like *RoboTron 2084* and *Defender* may seem somewhat tame. Although Peter Buse, adding to Marsha Kinder's observation that video games cater to masculine culture, suggested that simply by being about mastery through repeated loss arcade-style games are biased toward traditional male players. This is consistent with Sheri Graner Ray's 2003 findings in *Gender Inclusive Game Design: Expanding the Market*, in particular that being taught only through punishment without prior warning can disproportionately push away female players.

In *The Hegemony of Play*, Ludica argues that a number of factors ingrained in digital games contribute to the gender division in the videogame industry and players:

- Automated enforcement of rigidly defined rules removes the need (and opportunity) to socially determine house rules
- Emphasis specifically on high level spatial skills may render videogames more difficult for female players
- Simple machine opponents are typically tuned to present steep and consistent difficulty, which inflexibly favors only one purpose and approach to play

These male-biased characteristics are not unique to digital games, however. Whereas Leslie Haddon separately traced the challenges of gender bias back to MIT's labs in the 1960's, attributing the male preference in part to the games meeting the interests of the males creating them at the time, similar issues emerged with pinball. While these aspects of the games may have turned off many potential players, they came about partly as a result of trying to create a new type of game that could function as its own self-contained operator and referee.

CHAPTER 3

MACHINE AS OPERATOR, PLAY SPACE, AND OPPONENT

A few key innovators in pinball history–David Gottlieb, Harry Williams, Ray Maloney, and a handful of the engineers that worked directly with each of them–are responsible for a disproportionate number of inventions that together compose pinball in its modern form. Groundbreaking games often included several innovations at once, each irreversibly changing the standards for every pinball thereafter. While the pinball machines most similar in gameplay to coin-op videogames are those from the postwar era, the development of each individual element combining to create that style of game emerged in the decades prior.

The pinball industry established the business and gameplay patterns built upon by coin-op videogames in the 70's and early 80's. Part of design is prioritizing and addressing problems. One way that we can inspect game design practices is by studying what problems that they aimed to address, giving particular attention to the ways in which they did or did not succeed in doing so.

Throughout this chapter I tend to assume a greater degree of reader familiarity with coin-op videogames than with historical pinball. There are three reasons for this: (1.) my primary audience is fellow digital media practitioners and theorists (2.) pinball's developmental history is less commonly addressed in modern literature on game design, and (3.) readers are less likely to have firsthand experience with historical pinball machines, since the form took shape decades further back in history than the market

realization of coin-op videogames[11], and cannot be reliably 'ported' to modern platforms in the same way that has helped keep coin-op videogames from the golden age relevant[12].

When introducing important features of historical pinball, I will attempt to explain each in a way that can be understood by a reader unfamiliar with pinball traditions and terminology. On the other hand, when referring to coin-op videogames like *Space Invaders*, *Pac-Man*, and *Donkey Kong*, I am assuming some measure of prior familiarity with these games, or at least trusting that additional information about them and ways to still experience them are more easily found.

This investigation begins with flipperless pinball, referred to here as 'coin-op bagatelle' rather than pinball partly on account of the modern player's tendency to regard flippers as an essential, defining feature of the pinball machine and pinball play experience. Although the distinction will be clarified below, in these contexts 'bagatelle' is often being used as short for 'parlor bagatelle'. Full bagatelle is a much older family of simple table games that focus on direct target shooting in billiards-like play. Parlor bagatelle is instead designed around the variable-power shot along the side of an inclined table having an arc at the opposite end–the same basic play interaction still common via spring plunger at the start of nearly all pinball games to this day.

This distinction between bagatelle and pinball, as the terms are used here, is also of special importance to my argument. The introduction of flippers to pinball marked a major turning point for the industry. Core gameplay shifted away from one plunger shot per ball, toward focusing instead on mastering quick and correct reactions to use each ball longer and more effectively. Nevertheless it's common among pinball enthusiasts, game designers, and historians to refer to the flipperless games beginning in the 1930's

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[11] For perspective on point 3, all of pinball's earliest innovators have passed away, and surviving engineers that later worked directly for them are nearly 100 years old. By contrast, the designers and businesspeople driving the golden age of coin-op videogames are now mostly in or around their 60's.
[12] I cover some of the many major differences between pinball videogames and real pinball in Chapter 6.

(or even the 1870's) not as bagatelle but simply as pinball. This difference is why I specify postwar pinball, rather than pinball in general, as the family of games having the most in common with coin-op videogames from the golden age.

Pinball Machine as Operator, Play Space, and Opponent

Pinball pioneer David Gottlieb grew up working odd jobs, a few of which involved facilitating various carnival games (Kent 1). Some games required more operator involvement and attention than others, and if a game could handle most–or even all–functions of the operator, this could avoid the need to pay someone to facilitate the game[13]. Not needing to pay a full-time operator per game had the potential to both increase the bottom-line for game owners and decrease play costs for players, which were especially pertinent during the Great Depression when most of these innovations came together. *Baffle Ball*, David Gottlieb's first mass-produced game, was created in 1931. This reliance on the machine to automatically invite, facilitate, oversee, and reward the player's actions was also central to the coin-op videogame experience later that century, however videogames were able to build off this existing tradition and business channel.

Machine as Operator

David Gottlieb based the gameplay of *Baffle Ball* on parlor bagatelle. Parlor bagatelle originated nearly a century prior, as a lower-skill, high-chance alternative to the game of bagatelle, which itself was a pool-like game focused on target shooting (*Pinball 1* 20).

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[13] A short passage in Roger Sharpe's *Pinball!* inspired this angle, although Sharpe focuses on Gottlieb's competitor Harry Williams who began as a refurbisher/reseller (24). In reference to hearing about a coin-operated cork flipping game, Sharpe wrote that Williams thought, "My lord… I don't have to be out working. Those things could work for me." I opt here to focus on Gottlieb as the earlier inventor in the coin-op bagatelle space. The thought ascribed to Williams was somewhat hypothetical anyhow in order to better contextualize the series of historical events, which is roughly the same approach that I extend here.

Figure 9 Traditional parlor bagatelle table. Photo by Wayne Namerow.

What makes parlor bagatelle different from conventional bagatelle is that rather than shooting directly at targets, the player instead powers the ball up the side of a tilted table into an arc, varying the impulse applied as a way to control which scoring pocket a ball rolls into on its way back down the table. Traditionally players used a mace–a wide-tipped pool cue–to push the ball up the side, though Montague Redgrave patented a version of the game in 1871 that replaced the mace with a spring-plunger. Although these games structurally similar to *Baffle Ball* existed 60 years prior, innovations in *Baffle Ball* and related games built in the early 1930's made it possible for these machines to play the role of operator. This helped transition parlor bagatelle from a commoditized pub game into mass produced games with unique branding and personality, beginning the pinball and coin-op videogame industry.

Figure 10 *Baffle Ball* table. Photo by Harold Balde.

Carnival games operators serve a number of roles, each of which *Baffle Ball* and its successors aimed to account for:

1. The operator understood and acted on specific knowledge about proper set up and reset of game equipment.

Baffle Ball requires no knowledge of set up. Rather than needing an operator to arrange separate parts between plays, as for example when stacking empty milk bottle targets between players, the game fit together as a single piece. This made it unnecessary to have an operator present to oversee the game's set up. In the domain of other types of physical games, this also took the form of needing access to a full set of properly kept baseball gloves, playing cards, Go stones, or whatever other pieces a game required. Offloading this to an operator saved the player from the hassle of set up, clean up, and concern for losing or maintaining pieces. Offloading this to a mechanical or electrical machine in turn saved the game’s owner the same trouble.

2. The operator invited and challenged passersby into playing the game.

Prior to *Baffle Ball*, parlor bagatelle products were fairly standardized and impersonal in style. The play surface was either unpainted, finished wood, or a billiards-like cloth surface. In contrast *Baffle Ball*'s play surface, target cups, and balls are all vibrantly colored and arranged in a balanced, visually appealing layout. Through its ornamentation, which was partly play-relevant and partly decorative, the game's surface acted not only as the space for play, but also as an eye-catching advertisement announcing the game's presence in a room. For traditional carnival games, a barker largely accomplished this attraction aspect: "Step right up!"

In a 2009 *Chicago Tribune* interview, long-time pinball designer Steve Kordek explained that, "The secret to designing a good game is to attract the player… What attracts a player, first, is the pictures on the backglass of the game. Second, if what he sees on the playfield is different, that's a success." (Pevtzow) In 2012, an application's icon in the App Store has to appeal to potential customers, or a box's packaging design on the retail shelf needs to draw their attention; in the case of coin-op games, from 30's bagatelles to modern arcade titles, the machine itself had to serve that role.

3. The operator could, when needed, explain how to play the game.

A gold-painted box in the bottom-right corner of the *Baffle Ball* playfield reads:

INSTRUCTIONS
Insert coin in slot and
push forward.
To release one ball at a
time pull plunger at ex-
treme right

In the opposite lower corner, another similar box details the game's rules:

RULES and SCORES
If you shoot a ball in a pocket
of the same color as the ball,
that doubles the score of that
shot.
If you get a ball on the Baffle
Point that doubles the score
of the entire table providing
you do not knock it off again.

Additionally, each scoring cup and section along the bottom tray bears an explicit numerical label: 10, 40, 250, 400, 500. The score was simple addition and multiplication. This simplicity was especially important within the first half of the 1930's, during which time score tabulation was still left up to the player.

In less than a minute, without requiring anyone else's time for explanation, and by reading less than a page of text, a player of average intelligence new to the game could understand the operation and goals well enough to play. Note that, "well enough to play," is not necessarily the same as the player understanding everything about the game or its scoring, some of which the player discovers through experimentation. By presenting the rules out of the way and in written form, players already familiar with the game are able to skip them, replaying immediately without waiting through repeated instruction.

4. The operator handled money, restricting access to play materials until paid.

Above the instructions on the playfield, gold text clarified, "10 Balls for 1¢" (as the game grew in popularity, later models changed this to offer only 7 or 5 Balls for 1¢). Glass over the playfield prevented players from simply manually repositioning or resetting the marbles. This pattern of coin-operated access was borrowed from a bagatelle designed by Arthur L. Paulin earlier in mid-1931, to which Earl Froom had introduced

the playfield glass and coin mechanisms (Automatic Industries, Incorporated, '*Whiffle Board*')[14].

When studying these older arcade-style games, it's important to not lose track of the significance that paying per play has on the gameplay experience. Even without a financial reward at stake, the player invested money upfront in playing each round, and may consequently feel more pressure to get the most out of that payment, and excitement over doing so. Put another way, that payment barrier lowers a player's likelihood of simply fooling around. This increases the likelihood of concentrating to do as well as possible, or if practicing, to practice in a deliberate way to still justify the expense.

5. The operator provided the player with encouragement and feedback.

Another way that a carnival game's operator can help drive business is through calling attention to partial or near success. Phrases like, "So close!" or, "You got two of three. Next time!" can help the player feel like as though by playing again, there are decent odds of ending on a better round. The operator might offer emotional support, taunts and challenges, or whatever else needs to be said to get the player to play again.

Gottlieb's game provided distinct subgoals, and rewarded their achievement. These increased opportunities for a player to feel successful in discrete ways. As explained on the rules card above, in addition to simply trying to maximize score, *Baffle Ball* also featured two distinct goals: (1.) catch a ball in the Baffle Point–a shallow divot at the top-center of the playfield–and (2.) land each ball in the cup matching that ball's color. The independent nature of these challenges made it possible for players to feel encouraged by partial victories, in a way that simply accumulating slightly more or fewer

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[14] Charles P. Young's "Coin Game Board" in 1892 also possessed these two features, however there is no clear connection between that machine and those entering the market in the early 1930's (Automatic Industries, Incorporated '*Whiffle Board*').

points might not stand out as much. A *Baffle Ball* player scoring either a Baffle Point or matching a ball with its pocket color can process those as specific moments of achievement. Even accidentally landing a non-matching ball in another color's scoring cup can inspire a bit of hope for the next round; confident that she can land a ball in that cup, a player knows that next time they only need to perform that same action again, albeit with a different ball.

Coin-op videogames often offer independent subgoals as well, to similar effect. Even though it all translates into points scored, a *Pac-Man* player might succeed at collecting each fruit item that appears during one round, eating all four ghosts on a single power pellet, or clearing the game board of all pellets before losing a life. A player accomplishing any one of these subgoals earns a memorable and encouraging sense of achievement.

Although *Baffle Ball* did not incorporate audio feedback, sound is another mechanism that has a long history in providing feedback and encouragement for games in this family. Redgrave's *Improvements to Bagtelle* in 1871 included physical bells on the playfield at the center of scoring cups, creating a satisfyingly distinctive sound to mark the player's achievement. A few years after Gottlieb's *Baffle Ball*, in 1934, competitor Ray Maloney of Bally produced one of the first coin-op bagatelle to use electricity (PAMCO '*Contact (Senior)*'). Power was used for solenoid kick out holes (a feature still common in pinball machines to this day) and to power doorbell-like chimes (Ibid.). These machines were designed to recognize, distinguish, and even announce achievement, in order to fill in for the operator that historically performed that part of the experience.

Another form of feedback from the operator was non-verbal, but aimed at controlling the general percentage of player wins to maintain a sense of fairness and challenge. For carnival games, this might come down to subtle adjustments in bottle arrangement to affect how easily they will topple, making it possible to improve an inexperienced player's chance at a prize or to keep an experienced player from going

home with everything. In the case of pinball and coin-op arcade games, too many extra balls and extra lives were bad for coin drop, while too few were bad for player confidence.

The old manual adjustment system, still used in machines well into the 1990's, involved drilling multiple holes for outlane posts, hidden by these same posts, which location owners could reposition to make a game drain more often or less (Kamoroff 42). In 1982, the coin-op videogame game *Xevious* offered operators an option to adjust the number of points needed to earn extra lives. The pinball game *High Speed* in 1986 went further, setting a new standard by giving operators a setting to have free replay score milestones automatically adjusted every 500 plays to only award plays a certain percentage of the time at a given location (*Williams High Speed Instruction Manual* ii).

6. The operator handed over prizes when earned.

When carnival game players succeeded at a game's objective, the operator was responsible for doling out an appropriate reward. Carnival rewards have taken a variety of forms over the decades, from cheap plastic toys to low-end home electronics, with stuffed animals as a mainstay. Pinball machines as early as 1935 dispensed tickets for gameplay achievements, which then could be exchanged for replay or prizes (Rock-ola '*Flash*').

Baffle Ball did not yet account for this function of the operator. It was entirely up to the local barkeep or other device owner to reward high scores, if at all. In response to this weakness, in 1934 Bill Bellah invented and patented the replay feature. This design pattern gave a player the next round free in exchange for achieving specific in-game targets or goals. Harry Williams was the first person to implement replay reward, which he did in 1935 (Keeney '*Quick Silver*'). Giving away free games was ideal as a renewable prize since it required minimal overhead. It demanded nothing more of the operator than the negligible wear and tear of another play, a bit of electricity, and another minute of the

machine being inaccessible to other paying customers. The prospect of earning free plays proved an incredibly successful incentive, more than compensating for the occasional opportunity cost of the machine being in use a little longer.

Because coin-op games associated a round of play with a fixed cost, whether a penny at first or several quarters in more recent decades, earning a replay or extra life had real value to players. The value of a free replay was so tangible that it contributed to pinball's complications with the gambling laws throughout the mid-century. In 1960, David Gottlieb's son, Alvin Gottlieb, introduced the concept of Add-a-Ball–an analog precursor to the Extra Life / 1UP feature in coin-op videogames–as a workaround for these laws. Careful attempts to avoid slot machine regulations are why many pinball machines, from *Baffle Ball* up to modern tables, include prominent stickers or text declaring, "A Game of Skill, For Amusement Only" (wording as it appears on *Baffle Ball*) or "For Amusement Only, No Wagering." A separate branch of pinball history and industry, pay-out machines and bingos, played more deliberately to the gambling market as mechanical slot machine alternatives since the 1930's, which overseas in Japan took shape into pachinko games still played to this day ("Pachinko History").

For the first few years following *Baffle Ball*, score had to be manually tabulated by players or location owners. That approach worked for such simple games, in which the only scoring events were based on where the balls came to a stop, but were unsuitable for more advanced games in which touch-and-go mid-field collisions could confer point value. With the introduction of passive scoring bumpers (not to be confused with the later common "jet bumpers" that bash balls away on contact) in 1936 for *Bolo*, and later that year in the aptly named *Bumper*, electronic scoring became possible, and the machines then completely automated score calculation. This innovation, in turn, indirectly had an impact on how well the machine could fulfill the operator's job of recognizing and awarding achievement, since by the machine 'knowing' the player's score later games were able to associate score milestones with special gameplay awards (free play, tickets,

or beginning in 1985 with *Chicago Cubs "Triple Play,"* bragging rights by saving initials with high scores).

Figure 11 *Bolo*. Photo from ipdb.org (Pacent Novelty '*Bolo*').

Prior to the introduction of flippers in 1947 via Gottlieb's *Humpty Dumpty*, each ball shot onto the playfield lasted only a few seconds at most. With the addition of flippers, however, a more granular variation of the Replay Feature or Add-a-Ball took shape: through skilled performance the player could considerably prolong the duration and scoring opportunities of each round.

7. The operator prevented cheating.

In a carnival environment, part of the operator's role is that of referee, ensuring for example that the player does not step past a certain line. Physical hardware provided these same restrictions on player behavior. In addition to the use of glass to separate the

playfield from the player, mentioned earlier as an innovation from *Whiffle Board*, coin-op bagatelle and pinball machines employed a number of other techniques to prevent or punish cheating.

Each of *Baffle Ball*'s scoring cups had a one-way tilting gate hanging in front of the upward openings, to prevent a player from reorienting the machine in an effort to reposition balls after completion. The scoring tray along the bottom, divided into pockets worth fewer points than the mid-field cups, was separated from the rest of the play surface by a considerable drop, which kept the balls from being rolled back toward scoring cups.

Early coin-op bagatelle games were built to sit on a countertop (Gottlieb '*Baffle Ball*'), although legs were available as an option at extra cost (Bally '*Ballyhoo*'). Legs quickly became a standard part on pinball machines. In addition to saving counter space this made it more difficult to cheat at the games by turning them upside-down (*Tilt*, 4:22).

Another grandfather of pinball entering the coin-op bagatelle business in the 1930's, Harry Williams, observed players in 1933 slapping the bottom of his *Advance* tables as a way to temporarily open gates to high score areas that were intended to only open for special shots. As a temporary fix, Williams hammered fine nails into the base of the table to discourage striking it there (Sharpe 27). As a more practical mechanism for later machines, he invented what he called a Stool Pigeon, consisting of an extra ball carefully cupped atop a pedestal in an area separated from the playfield. If the machine was struck or moved too violently, the ball fell off the pedestal, which the game's instruction card made clear voided any score shown on the playfield. When the next player reset the game with a new payment, along with the balls dropping back into their

hopper the stool pigeon pedestal sank far enough for its ball to roll back on, after which it popped back up into position.

Tilt mechanisms took on a variety of different forms in the years that followed, each specifically designed to counteract a particular form of abuse[15] (pendulums to detect lateral force, a ball rolling on a track to measure the front being lifted, slightly separated electrical contacts to detect being kicked, etc.). Depending on the era, manufacturer, and type of tilt mechanism thrown, penalties varied from a telltale light, to loss of the current ball in play (temporarily cutting power to flippers), to instant game over and reset of the machine. The important point, of course, is that these features further completed the functions traditionally expected of an operator, making the machine suitable for standalone, self-contained, unmonitored play.

There are more advantages to removing the operator than simply having one less employee to pay. Whether on account of a player's mood or personality type, or perhaps some feature of the potential working attendant, a player may prefer to not deal with another human being as part of learning, playing, or replaying a game. Although pinball and coin-op videogames were both played in public, no other person as either operator nor as opponent was necessarily paying attention to a stranger's play.

With another person paying attention, a player may be self-conscious about their mistakes, and/or self-conscious over needing to (and spending ever-more money to!) restart so frequently. The lack of personal interaction necessary for coin-op gameplay largely protects the player from these pressures. The pinball industry benefitted from this

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[15] Some modest amount of nudging and shifting is intended as fair play with pinball, as is partly evidenced by pendulum tilt components being adjustable in sensitivity and number of contacts allowed per game (Kamoroff 42). Tournament players, pinball collectors, and pinball designers all incorporate physical force, short of throwing the tilt sensors, as part of their normal play techniques (*Tilt*). Performing this part of pinball play, unlike the press and release of the buttons or pull of the plunger, does involve full body balance and practiced muscular coordination. Additionally, on account of the substantial weight of pinball tables, this type of interaction also gives adult players an advantage over youth.

since it lowered the friction of both first-time play (without fear of comments or even the unspoken judgment over inevitably poor early performance) and replay (more easily taken to an extreme that any sensible person might feel ashamed to have another person witness).

Machine as Play Space

A traditional carnival game, in addition to requiring an operator, required a booth long enough to challenge throwing accuracy and wide enough to display an array of prizes. Most non-pinball mechanical and electromechanical games presented similarly difficult demands on space and mobility, whether a shooting gallery or submarine game (Kent 265). Pinball machines, though seeming quite heavy and large by contemporary standards–with a 27x55 in. footprint and typically weighing several hundred pounds–compared to many coin-op alternatives in the 50's and 60's these games were much easier to find space for, rearrange without special assistance, and move into storage if needed.

Between the lack of need for an operator and the comparative ease of placement, pinball machines were able to break out of specialized midway arcades into a variety other public settings, including "airports, laundromats, restaurants, pharmacies… fast food stores and shopping malls" (Flower 15). Being able to place the machines in a wider variety of locations benefitted every strata of the pinball industry, from the manufacturers able to find more distributors, to the distributors able to find more buyers. Buyers and players alike benefitted from the games being more widespread: increased familiarity increased the likelihood of players impulsively feeding coins to machines found on-location, while pinball players enjoyed an explosive increase in the variety and quality of pinball machines resulting from the fierce competition racing to keep up with demand.

Machine as Opponent

Unlike most carnival or pub games, in which a player initiates each action but reaction is never challenged, and unlike many historical single-player games, in which players advance game state through decisions made in turns, with the 1947 introduction of flippers pinball became a single-player game centered on mastery of quick, consistent reaction. Carnival games historically let the player throw or shoot, but did not require that they catch or dodge; games played alone historically let a player puzzle between one decision and another, though they rarely required or rewarded sharp, practiced reflex.

Prior to flipper-based pinball, games of quick and appropriate reaction typically required another human opponent, often taking the form of athletic competition, as in boxing, fencing, and tennis. Although modern videogames have established quick reaction challenge against a machine as a now fairly common form of play, such interactions might have seemed quite strange, even largely impossible, prior to pinball. As Greg Costikyan noted 1994, solitary games are somewhat unusual in the history of games ("I Have No Words and I Must Design").

A few pinball games attempted head-to-head simultaneous multiplayer, including the 1971 Gottlieb game *Challenger*. These games were extremely unsuccessful in the marketplace. Fewer than 150 *Challenger* tables were manufactured, many of which were built to satisfy a single order by a buyer that David Gottlieb himself desperately tried to talk out of such an economically unwise purchase (Sahlhoub *Pinball Compendium, 1970-1981* 33). The concept seemed promising enough to be designed and built; in practice the market rejected all attempts at it. It's worth noting that while head-to-head coin-op videogames later found a clear foothold, from *Pong* and *Warlords* to *Street Fighter II* and

beyond, in all such cases for coin-op videogames a single-player mode played again basic artificial intelligence was included as a way to practice when alone[16].

Figure 12 *Challenger*, a head-to-head pinball game. Photo by Mark Clayton

Instead of head-to-head simultaneous play, the multiplayer option provided for most pinball machines followed the option invented in 1954 by Wayne Neyens: turn-

[16] Head-to-head physical table games including foosball, table hockey, air hockey, and others in that family also seem at this time to be an largely understudied area of historical game design. However the lack of powered button action, static narrative theme, and single-player modes in these games render them perhaps closer to the history and design of multiplayer games like ping-pong and pool.

taking asynchronous multiplayer (Gottlieb '*Super Jumbo*'). Each player alternated trying to independently outperform their peers in overcoming the machine's layout and scoring features, in effect still operating as a player-vs-machine game[17].

Another inversion from the established norm was that whereas carnival games typically involved a clear win condition–knock over all three bottles, ring the bell, and so on–beginning with the introduction of flippers, pinball score became theoretically boundless[18]. This meant that not only was the machine serving as the opponent, the game was now an opponent that could not be completely defeated. No matter how well a player did, and no matter how long the player lasted, there was always more room for improvement in higher scores and longer play times. This helped increased the machine's coin-drop, since revenues were directly tied to replay. If the designer included a way to decisively win they might simply move on after successfully conquering the game.

Given the unbounded nature of pinball play, in which a given session might consist of a single quick round or hours of feeding the machine, freedom to play without a second player present decreased the barriers for the machine to stay busy. For a game that necessitates two players, the game session comes to an end just as soon as either player becomes disinterested or needs to go; the player-vs-machine format makes it easier for a lone player to practice a game to the fullest limits of their own interest, time, and budget.

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[17] In an interview for the Wizard Mode extras of *Pinball Passion* (17:39), Wayne Neyens explained that although 2-4 player turn-based pinball machines were able to sell for higher prices, meter tracking from the machines revealed that, "90% were played with one player, and maybe one percent or half a percent played with four players. Just the opposite of what I thought it was going to be." Neyens explains that his motivation for 4-player was partly that it increased the odds of at least one player winning a free play, which would keep the other three friends in the arcade longer (Ibid.).

[18] Prior to the invention of flippers, a maximum possible score could be calculated, although the improbability of that occurring even by a practiced player kept it from being an especially meaningful number. In practice, too, the score on all machines has a practical upward limit determined by the number of digits, lights, or data type used by the machine to store score, and especially for older machines pinball experts can "rollover" the score by exceeding the machine's display or storage limitations. This type of achievement parallels the way that classic coin-op videogames high score enthusiasts can reach "kill screens" in cyclical games like *Donkey Kong* and *Pac-Man* by playing until the machine's level number overflows.

Coin-Op Videogames as Operator, Play Space, and Opponent

Coin-op Videogames Machine as Operator

Coin-op videogames, in the same ways and sometimes to an even greater extent, accounted for the same functions of the carnival game operator:

1. The operator understood and acted on specific knowledge about proper set up and reset of game equipment.
2. The operator invited and challenged passersby into playing the game.
3. The operator could, if the player was new, explain how to play.
4. The operator handled money, restricting access to play materials until paid.
5. The operator provided the player with encouragement and feedback.
6. The operator handed over prizes when earned.
7. The operator prevented cheating.

Coin-op videogames also operated as self-contained play space. Technological limitations of early machines often confined gameplay to single-screen environments, on which every threat and opportunity could be simultaneously identified. With the introduction of scrolling games like *Defender* (developed within Williams by Eugene Jarvis, a former pinball programmer) machines became capable of self-containing far more "space" than their physical machines occupied.

In the majority of coin-op videogames during the golden age, the machines provided the primary (often only) opponent. The already highly complex electrical and mechanical features of pinball machines pushed the limits of what types of mechanics and challenges could be affordably and reliably created from moving physical parts. The game mechanics possible for an automated challenge within virtual space–even

accounting for the constraints of early technology–rapidly exceeded what is possible with physical parts.

Arcade-style games, played in public settings with short rounds of play, are a novelty business. Companies participating in the market space faced constant pressure to make their games look and feel new, different from both the competition's offerings, and even the same company or designer's previous games. Pinball historian and collector Michael Shalhoub credits Ed Krynski with "[design of] more games than anyone in the history of the industry." Kyrnski described his process to Shalhoub in a way that highlighted the pressure to differentiate: "Most of the ideas developed from a 'gimmick,' a need to come up with something different" (Sahlhoub *1970-1981 Compendium* 20).

In representational and gameplay variety, coin-op videogames possessed an inherent advantage in the flexibility of their medium. Though lower in fidelity than the experience offered by playing pinball, early coin-op videogame hits *Space Invaders*, *Lunar Lander*, *Asteroids*, *Defender*, *Xevious*, *Galaga*, and *Zaxxon* showed a greater range of visuals and gameplay features, even purely among space-based games, than could realistically be expected between two pinball machines even if based on completely unrelated themes.

Coin-op Videogame as Play Space

Part of what made greater variety of play experiences possible with coin-op videogames, relative to that offered by mechanical play, was that for digital games the basic physical concepts of space, time, matter, and representation had to be reinvented for each game. The fundamental movements in *Pac-Man*, *Joust*, and *Missile Command* are completely different in their handling of acceleration and collision. By contrast, every physical pinball machine ever produced has necessarily been built upon the same fundamental 'implementation' (that being natural law) of acceleration and collision, varying at most through differences in material selection and mechanical assembly.

Sherry Turkle, in *Video Games and Computer Holding Power*, explains a similar distinction between pinball and videogames to the one that I am highlighting: “Pinball games were constrained by mechanical limitations, ultimately by the physical laws that govern the motion of a small metal ball. The video world knows no such bounds. Objects fly, spin, accelerate, change shape and color, disappear and reappear. Their behavior… is limited only by the programmer’s imagination.”

However despite this apparent freedom to redefine the simulated fabric of space, time, and representation on a whim for each coin-op videogames, aside from variations in tuning and implementation, designers of golden age coin-op videogames generally stuck to crude motion simulation, in real-time, with collisions as the primary causal event. Laser projectiles crashed into aliens, monsters touched the hero, and (most) characters whether good or evil could not pass through walls.

Another cause for overlap in handling of play space is that many coin-op videogames from the golden age, in part on account of technological limitations, took place entirely within a fixed, non-scrolling space constrained by (or wrapped along) the edges of the display. By keeping every element and area of the playfield simultaneously visible, these games could not be about exploration or adventure, sticking instead to skill mastery and basing replay on fresh attempts at the same stressful task. This constrained the gameplay genres, and thus play styles, in early coin-op videogames.

Coin-op Videogames as Opponent: Virtual Motion

The coin-op videogame designer's concern with physics and simulation-like representation was clearly selective at best, not only in response to technical limitations but often with consideration for effects on gameplay. The ball in *Breakout*, contrary to the expectation of modern players, destroyed only one brick per each bounce from paddle or back wall, otherwise passing directly through any other bricks on its return trip. Jumpman's hammer, in *Donkey Kong*, simply vanished when he was done with it. The

player's ship in *Galaga* cannot move forward nor backward, and Little Mac in *Punch-Out!!* cannot move at all without immediately returning to his place. *Bubble Bobble* involved alternatively creating and destroying seemingly endless amounts of mass. *Tetris* employs a Carrollean take on gravity, combined with sharp 90-degree rotations that, necessarily for gameplay, never collide during the instantaneous reorientations. Games like *Tempest* and *Qix* look more like laser lightshows or early *Windows* screensavers than they do like anything physical–and yet, both games, like all games just listed, still mostly respect continuity of space, in real-time, using collisions as the primary causal event.

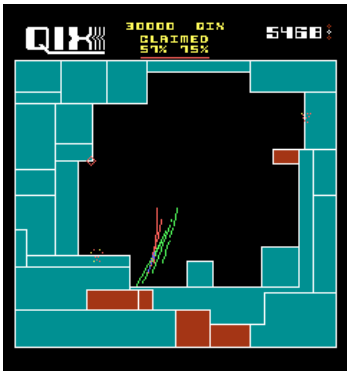

Figure 13 *Qix* is a highly abstract game, yet still based entirely on motion and space. Image from Arcade-Museum.com.

Emphasis on objects moving around and colliding may seem obvious, at first perhaps even like the only option. Consider however that across all mediums, there are countless examples of games that do not take place in continuous space or in real-time. Card games and board games, for example, take place almost exclusively in discrete or completely abstract space, generally proceeding in turns. Part of what made parlor bagatelle a suitable foundation for David Gottlieb's initial venture into automating and obsoleting the operator, instead of setting out a pack of cards or a checkers board, is that there is a fairness, perhaps obviousness to how objects move through continuous space.

Unlike a board or card game, in pinball the laws of physics handle the consequences of action between player inputs, so that the player does not need to learn nearly as much in order to simply play. Spatial relationships, movements, and collisions convey a tremendous amount of information that we understand intuitively from our casual interactions with the world. We can visually discern a near-miss from a complete miss, we can extrapolate current movements and positions to anticipate what might take place next, and we can adjust our next input action within a smooth continuum (amount of force for plunger, timing of button press) in proportion to how much we missed on our previous attempt.

While the same basic natural concepts of space, time, and player reaction are at the core of sports activities, as well, there is a pivotal difference the nature of real-time reaction gameplay common to both postwar pinball and golden age coin-op videogames compared to sports. That difference centers around an invention that became a main part of the arcade-style play in the late 1940's, not coincidentally at the same time as the flippers: the digital button. The ramifications of that component as a mechanism for increasing accessibility and replay value with a relatively low-content game will be explored in-depth the following chapter.

CHAPTER 4

DIGITAL BUTTONS FOR REAL-TIME PLAY

In November 1932, a year after Gottlieb's *Baffle Ball* kicked off the pinball industry, a company in Louisville, Kentucky produced a baseball-themed mechanical game played with an on-field bat (Hoosier Games Company '*Hoosier Baseball*'). *Hoosier Baseball* features a knob that, as it gets pulled, pivots the bat on the playfield. Gameplay consists of trying to use this bat to knock a ball 'pitched' (rolled) down the field back up to the other end of the table. *Hoosier Baseball* was by some measures ahead of the curve, for example by employing solenoid-powered kickout holes (to represent running bases) a year before similar inventions were added to pinball machines.

Despite this machine having both electromechanical (EM) components and a swinging bat, unfortunately the two were not yet combined into an electromechanical flipper. By the time Harry Mabs created the EM flipper in 1947 for D. Gottlieb Co., installing six on the playfield of *Humpty Dumpty*, many games had already appeared with manually powered bats like the one in *Hoosier Baseball*. It's really the button-activated, powered EM flipper that revolutionized pinball, and thus the arcade game industry, not simply the flipper itself.

Pulling a knob to swing the flipper, via direct mechanical force, results in an inconsistent force over time. Additionally, as in real baseball, the player has to swing for a moving target–as there was no inlane to trap nor cradle the ball against. These two factors compounded the challenge of swinging the bat at the right time with the challenge of swinging the bat correctly. This is unlike a pinball machine's spring-plunger, which is player initiated rather than timed in response to a moving stimulus, concentrating the difficulty on doing it correctly but not timing it. This is also unlike a pinball machine's

powered flippers, which produce highly consistent force when triggered, allowing the player to focus on timing rather than on applying proper power to them.

To investigate this distinction further, it helps to contrast what makes the physical, athletic batting experience of batting in baseball different from batting in T-ball. In baseball, hitting the ball requires the player to both correctly time and correctly execute a particular motion. An ideal swing executed with improper timing is just as much a problem as an improper swing with ideal timing. In T-ball, because the ball is stationary when struck, the element of timing is removed, leaving the player's challenge only in executing the swing action appropriately. In this situation the player can miss the ball, but it’s impossible to swing too early or late.

Here we'll find another EM game useful for comparison: *Upper Deck*, built by Williams in 1973. *Upper Deck* has a similar playfield to *Hoosier Ball*–it's also a bat game, rather than a full pinball–however instead of pulling a knob to move the bat, a button atop the machine closed a circuit powering a solenoid to electromechanically drive the swing. The powered bat in *Upper Deck* was of similar operation to the flippers that Harry Mabs created for *Humpty Dumpty*. With *Hoosier Ball*, it's possible to swing the bat with poor timing, or to swing the bat at a poor rate. In *Upper Deck*, because the bat swing is performed with consistent force each swing; the player only needs to be concerned with timing.

The predictability of the solenoid coil removes the skill of how to swing the bat, leaving behind a focus on more pure concern for proper timing. Roughly, baseball batting demands swing skill and timing skill, T-ball removes timing skill to emphasize swing skill, and a powered pinball flipper removes swing skill to emphasize timing skill.

Gone is the rich complexity of ways to swing a bat wrong or right, since the press of a button accomplishes this action instead. While there are fewer ways to swing the bat incorrectly in *Hoosier Ball* than in T-Ball, the context for these games made practically

any amount of trained dexterity inappropriate: these were novelty amusement machines, designed to be played without an introductory demonstration.

For button-powered action, the player does not need to be shown how to correctly perform whatever task is needed, nor is any explanation necessary to understand within what constraints that action can be performed. Whatever action the button produces is precisely what the player is allowed to do. This increases how easily new players can try these machines without need for detailed instruction.

Figure 14 *Upper Deck*. Note the flipper-like wooden bat along the bottom. Photo by Vic Camp.

Besides the joystick's left/right to run and up/down to scale ladders, *Donkey Kong* featured only one button for gameplay: jump. This leaves little need for detailed explanation to the player about how to manage the controls. The protagonist Jumpman (later named Mario for his future appearances) leaps a fixed height, at a fixed speed, with each press of that button. This consistency in operation makes it trivial for players to learn what to expect from each button press, so that the bulk of the difficulty becomes a

matter of timing the jumps over barrels rolling by at constant speed rather than struggling to merely perform the jump action particularly well.

Likewise, when the joystick is used to maneuver the protagonist of *Frogger* between traffic or drifting logs and turtles, even though the game takes place in real-time the movements happen in discrete, highly predictable units. The frog always leaps one lane at a time, or precisely the gap between adjacent objects on the river. It seems plausible to suspect that, of all the animals that might have been selected to cross traffic, the frog worked best for the gameplay need to move with quantified, predictable spacing.

The virtual nature of coin-op videogames makes it possible to take this responsiveness and consistency in action one step further: rather than having direct effect over the flipper to indirectly affect the projectile based upon the timing, position, and momentum involved in contact, action buttons directly and consistently affect coin-op videogame projectiles. Midway's 1976 coin-op videogame *Sea Wolf*, itself an adaptation of Sega's 1966 electro-mechanical game *Periscope* which used strings of lights under plastic 'water' to represent torpedo motion (Kent 83), challenges the player to hit moving targets across the playfield. Enemy ships and player projectiles in *Sea Wolf* were given constant velocity to facilitate gameplay focused on shooting projectiles at moving targets. *Paperboy* in 1984 turned this system around, giving the player constant velocity to fire newspapers at fixed speed toward stationary target–however since the camera follows the player's bicycle movement along a single direction the effect on gameplay is similar.

Games achieve broader and more immediate accessibility by using digital input for real-time gameplay rather than relying on complex bodily dexterity. Many real-time games–sports and other athletic competitions–require or strongly favor a particular type of body, involve risk of serious injury, and may require substantial physical conditioning to compete. For a real-time game that generates its revenues through more people playing more times, rather than through spectatorship and sponsorship, those barriers to entry would mean lower sales.

Among arcade coin-op devices, prior to creating *Baffle Ball*, Gottlieb focused on games like *Husky-Grip Tester* (Sharpe 33), "strength testers" that rated how hard the player could squeeze. These and other games of strength, such as the high striker (traditional hammer and bell carnival game), had limited appeal to players that did not have a certain body type.

Pressing a button to produce a consistent electrical action, by comparison, does not favor any body size, is not affected by bodily fitness, and practically eliminates risk of injury. This broadens the range of ages and fitness for players that can play these types of games with roughly equal opportunity. Mere practice–which of course generates additional revenue for the machine's operator–can bridge a performance gap, rather than the player needing to spend more time on conditioning in the gym. When Billy Mitchell set high score records for *BurgerTime* and *Centipede* he was under 20 years old. For players short or tall, thin or heavy, weak or muscular, button-based gameplay offered a comparatively level playing field.

Figure 15 Billy Mitchell in November 1982, photo for Jan 1983 edition of *Life* Magazine.

For many non-digital games, whether running for full-body athletics or just throwing darts, physical fatigue also poses a risk to replay. In the coin-op business, replays directly affect revenues. Digital button gameplay minimizes fatigue as well as generally reducing the impact of fatigue on performance, both by minimizing the amount of physical exertion involved[19]. Like a line of slot machines at a casino, many arcade-style games can be replayed arbitrarily many times given sufficient interest and coins.

Separating Strategy from Dexterity

If simple strength games, whether grip testers or high striker, were played entirely by pressing a digital button to produce a consistent action, the challenges of such games would fall apart. If the complex action of throwing a dart to hit an intended location on the board could be executed with perfect mechanical consistency, the game of darts would become a lot less interesting. The richness of these games is in the difficulty or complexity of that most fundamental task.

To investigate why the use of digital buttons in arcade-style games does not trivialize the activity in the same way, we'll turn briefly to the dart game Tic-Tac-Toe ("Dart Games & Dart Rules, Tic Tac Toe"). In dart Tic-Tac-Toe, players throw darts to zones on the board to earn X's or O's in corresponding tic-tac-toe positions:

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[19] There are some notable exceptions to this general rule, those being arcade games that demanded intense struggle from the player, such as *Track and Field*, or the button-mashing for grappling common in later wrestling-themed coin-op videogames. While further investigation might also include full-body dance games like the *Dance Dance Revolution* series, such games fall outside the scope of this thesis.

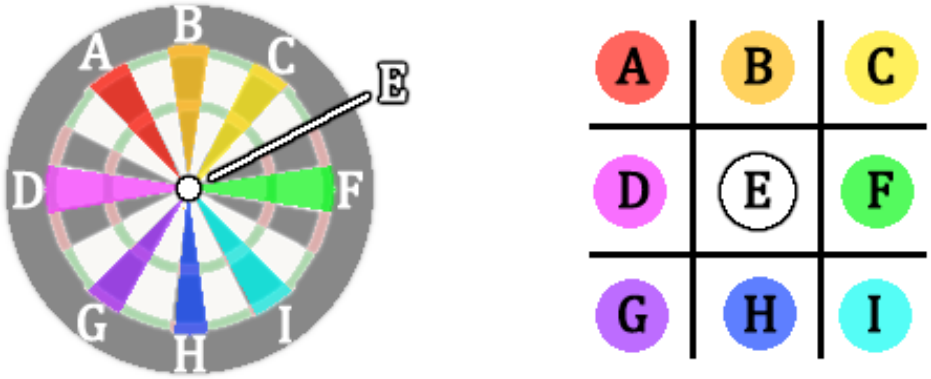

Figure 16 Colors and letters indicate the mapping between dartboard and tic-tac-toe positions. Illustration by Chris DeLeon.

Players take turns throwing darts at the areas indicated by the left illustration. After earning 3 points for any one area of the dartboard, that player places their mark on the tic-tac-toe grid. Hitting the multiplier rings scores 2 or 3 points at a time, earning the positions faster. The center square, E, is scored by hitting the bullseye. Grid positions are unchangeable once claimed.

Traditional tic-tac-toe, played on paper without darts, is a solved game. Solved, in this context, means that all possible moves have been considered, leading to the discovery that optimal play by both sides will either always end in a draw, favor whichever player moves first, or favor the player that moves second.

What gives depth and uncertainty to the darts version of tic-tac-toe is the difficulty and bodily coordination necessary to reliably throw a dart to any intended spot. Subtle variations in how a dart is held, when the dart is released, and how the arm moves for the throw can make the difference between landing in different scoring sections, even at expert ability. Given the certainty of at least some deviation from the planned destination, players need to aim for a point based not only on what will happen if the dart flies true, but also with consideration for what will happen if they miss by some approximate amount in any given direction (Tibshirani 224).

Consider if both players possessed superhuman skill at dart throwing, or perhaps were both replaced by robots aiming high-speed dart guns. Darts in this hypothetical scenario would always hit precisely the intended spot on the board, making dart Tic-Tac-Toe no different than traditional paper tic-tac-toe. Both players could, as when playing paper tic-tac-toe, always end the game in a draw by making decisions around the strategies already known to be ideal.

More realistically, what tends to happen instead is that if either player is significantly better than their opponent at accurately throwing darts, that player can simply dominate the game without much strategy. The winner winds up playing a variation of tic-tac-toe in which one side can occasionally take multiple turns in a row.

The more predictably and evenly the participants can execute these complex bodily maneuvers with consistency and accuracy, the more strategic the game becomes. That leads to success or failure being primarily a function of the decisions made, more so than the execution of those intentions. Conversely, the less capable both sides are of reliably executing those maneuvers, the more the outcome degrades into pure chance, favoring whichever player happens to first hit those targets that result in their victory.

A tennis swing, a basketball shot, or even a knockout punch can be aesthetically beautiful in the bodily performance for its execution, partly due to the incredible range of variability within those actions. In arcade-style games, the variability in basic actions is greatly constrained. Every player that fires a shot in *Centipede*, *Berzerk*, or *Galaga* performs that activity the same way. This reduction of complexity renders success or failure contingent entirely on the rapidity and accuracy of spatiotemporal estimations. Impressive feats are certainly still possible in the realm of pinball and videoarcade games, the difference being that their execution relies primarily on practiced or improvised timings of actions that independently are mechanically consistent, resulting in a space generally less dynamic and nuanced than performance of full-body athletic coordination.

Aside from a few advanced flipper techniques that involve extremely rapid taps, every press and release of a flipper performs the basic action with mechanical consistency. In coin-op videogames the press of a button performs the swing, shot, punch, or run, and it does so with perfect consistency. The difficulty in arcade-style games is usually not in trying to simply perform the most fundamental action.

Yet unlike games of strength, which would become meaningless by the automation of their core actions, arcade-style games retain some form of skill despite this type of automation. Nor do arcade-style games turn into a metagame of pure strategic decision making on account of this automation, in the way that darts Tic-Tac-Toe might in a match with players that throw perfectly. For arcade-style games, the player is not only dictating when to initiate actions but is also responsible for judging and timing reactions in response to cues in continuous time and space (either physical or virtual).

Continuum from Pure Strategic Decision to Coordination Complexity

Chess, like paper tic-tac-toe, is a turn-based game that takes place in discretely quantized space. Insofar as the movements in chess, like the movements in tic-tac-toe, are executed with absolute consistency following from user intention, comparing its input/decision experience to that of arcade-style games helps to show where the dart Tic-Tac-Toe analogy breaks down. As another reference point, golf will be used here as a turn-based game in which execution of intention is inclined to have greater influence on success than player decision.

Chess is not lost on account of failing to move a piece to its intended tile, and golf is not lost on account of failing to decide where to move the ball. In the case of abstract board games structurally like chess (including many other traditional classics such as checkers, Go, and Mancala), players take turns making discrete movements from and onto unambiguously distinct tile coordinates. For such a game, it hardly makes sense to consider the possibility of a player meaning to move a knight from g1 to f3, but somehow

fumbling that piece and accidentally landing it on h3, thus leaving their pieces in an unfavorably vulnerable arrangement. It would seem equally absurd to suggest that the player might undershoot, accidentally landing on g2, or overshoot, landing on e4. Nor, in the scope of any of this, could the piece meaningfully be halfway on f3, just outside the edge of f3, or otherwise in some state other than resting on a single tile.

Those same types of errors make perfect sense when talking about games and aspects of games centering on athletically coordinated skill, such as golf, taking shots in basketball, or batting in baseball. In each case, if play movements were a matter of pure decision, no player would ever do anything besides hit the ball directly into the next hole, score a 3-pointer every possession, and hit every pitch out of the park. In reality of course, success at these activities is not so straightforward. Failure can happen in degrees, whether overshooting or undershooting, and the outcome hinges on countless factors in bodily composition, concentration, physical limitations, and perhaps most importantly on the intensity and timing of muscular contractions drilled into tacit memory through repetitive practice.

Decisions made by players in those sports, rather than accounting for objectively knowable probabilities (as in Blackjack) or moves that can be proven to lead to a favored outcome (as in chess), instead have to gauge their decisions, such as whether to take a shot at any given moment, on soft and fluctuating variables like confidence, fatigue, momentary pressure, and state of mind. Playing pinball and *Space Invaders* likewise involves many of these same fluctuating, soft probabilities internal factors. Practice drills and in-game experience help players mitigate or account for these kinds of factors.

If a chess player drilled moving their piece from g1 to f3, that exercise would appear silly and unproductive. In contrast, if a golfer took for granted they could simply hit the ball anyplace they wanted, without drilling that movement, that would seem similarly ill-fated.

Pinball and coin-op videogames fit somewhere in-between. On the one hand, it's clear that neither consists of pure strategic decision-making, because like golf or basketball, people would just make the shots they wanted to make and play indefinitely. On the other, there's a major difference between swinging a golf club and pushing a button. Although there are learnable maneuvers having to do with the coordination and timing of button press and release, it's not at all obvious that practicing flipping a pinball or firing a laser in *Defender* makes sense in the same way that we'd expect someone to practice driving golf balls at the range.

Time-As-Pseudo-Analog Input

Although I refer here to the release of buttons as significant in their timing, they are often incorrectly imagined for both pinball and coin-op videogames as having an influence only at the moment when they are pressed down, as initiators of action. In both types of games, however, the impulse imparted is sometimes a function of what duration the button is held. Because the construction of a pinball flipper exerts upward force only while its input switch is depressed, *Pinball 101* explains (26:30) that a rapid press can hop a rolling ball to the other flipper (a "tap pass"), whereas a slightly longer tap will pop the ball up into a slingshot (a "Jeff pass"). By comparison holding the button longer applies an extended impulse with follow-through, sending the ball deeper and faster into the playfield (Pol and Rain 118). Similarly, in some coin-op videogames employing discrete button-style input for movement, the longer the button is held the more force is imparted, as for example in *Asteroids*.

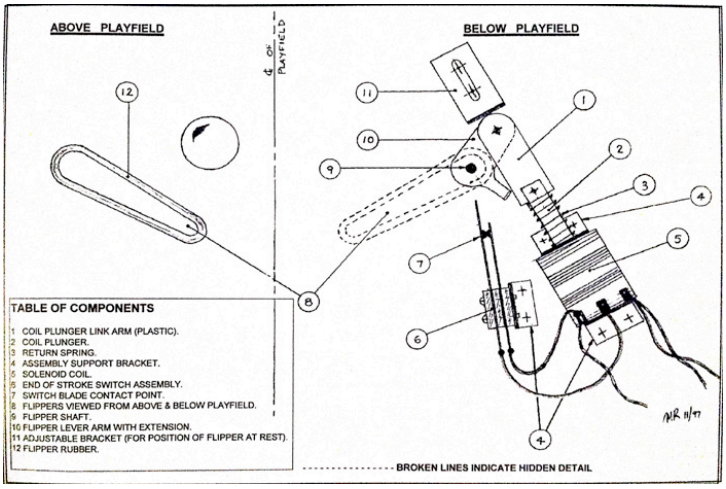

Figure 17 While the flipper button is depressed, electromagnetism pulls the armature (2) into the solenoid's center (5), raising the flipper (8). Image from Rossignoli.

In *Game Feel*, Steve Swink highlights that *Super Mario Bros* popularized a variation of analog-by-time-held input that has become common in the platforming genre: the longer the player holds the jump button before release, within a modest window of time, the higher Mario rises before falling. This feature still sees use in more recent games like *Ratchet & Clank* and *Little Big Planet*. Atari used the same pseudo-analog input for the jump mechanism in *Major Havoc* two years prior in 1983. *Joust* in 1982 used a different input mechanism to achieve a similar effect: each tap flapped the player mount's wings, giving the player fine control over altitude changes by the timing and rapidity of button presses.

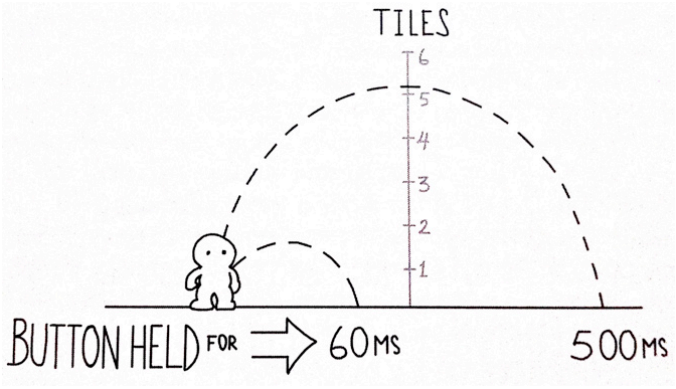

Figure 18 Mario's jumps higher and farther in *Super Mario Bros* based on how long the jump button is held down. Illustration from *Game Feel* (Swink 213).

Directional Input

Classic coin-op videogames are remembered for having joysticks alongside the action buttons, however in the years before joysticks were common on arcade machines for directional input (excepting, for a moment, games played with dial/"paddle"), buttons were often used for all inputs. *Asteroids*, for example, used separate buttons for left rotation and right rotation. Though *Defender* included a joystick on the cabinet, it was only used for up-down movement, with lateral motions controlled by a pair of buttons for thrust and changing direction. Lastly, though resembling modern analog joysticks in mechanical form and appearance, early joysticks for coin-op videogames primarily were used to provide digital input, producing either completely open or closed electrical signals depending upon whether the stick passed detection thresholds. Using a digital joystick, or later a directional-pad for home console systems, for interaction as opposed to separate action buttons helped provide a direct mapping to the motion caused, and also prevented players from simultaneously pressing contradictory inputs (Swink 88).

Real-Time Compared to Turn-Based Play

Except for the involvement of a digital button for expressing intention of action, the real-time reaction play of arcade-style games is closer to that of sports than most other game types. The necessity of humans enforcing game rules during play has often placed severe limits on the design of traditional games (Crawford ¶ 834). This limitation often led to primarily turn-based games, except that sports did not have this same design constraint since physical laws, rather than human judgment, upheld many of the fundamental rules about movement and space (Juul ¶ 644). Sports with more complex rules that played out in real-time typically necessitated one or more referees; athletic competitions that can be performed unsupervised tend to favor turn-based play to make the rules more manageable.

In soccer or racing, for example, compared to darts or golf, competitors perform simultaneously, in immediate opposition, rather than in discrete turns. However this particular distinction does not produce clean categories: sports like baseball and football showing hybrid examples that mix turn taking with real-time response. Even in such hybrid cases, we can study the real-time response portions of play separately from the turn-based structure in which the rounds proceed.

Anyone literate in how a particular sport is played could watch a replay in slow motion and point out what the losing player ought to have done differently: the batter should have swung sooner, the basketball player should have thrown their shot a little harder, and so on. The difficulty is not necessarily a problem with making the right decisions, but is instead due to scarcely having time to make decisions at all, or in failure of practiced actions to consistently achieve intention.

This time element is a constraint with cognitive and motor limitations, but practically speaking can become competitive at even smaller intervals. When reflex appears to exceed the minimum time separating perception from motor action, it's accomplished by a combination of predictive estimation and chance. In *Pinball Wizardry*,

Robert Polin and Michael Rain explain that due to the high speed achieved by a steel pinball on waxed wood–with bursts as fast as 4 meters per second during normal play–relative to the dimensions of the playfield, reaction time is insufficient to wait until an event is happening to respond to it (22). Polin and Rain refer to pinball as a "game [of] prediction, not reaction." Likewise, in *Asteroids* a player cannot wait until a collision is about to happen before beginning to dodge. In the later levels of *Pac-Man* where the ghosts move faster than the protagonist it's impossible to wait until nearly caught to evade. In *Missile Command* a player aiming directly at warheads will miss every single one of them.

Arcade-style games, both pinball and coin-op videogames, typically require the user to quickly and correctly time each response. As in athletics, the actual events responded to may take place in less time than a full cycle of perception-to-action, leading the player to either respond to leading cues (for example by flipping based on what's about to happen, rather than what is currently happening) or to minimize opportunities to be caught off guard (for example by avoiding proximity to dive bombers in *Galaga*).

Control of Pacing for Digital Button Play

As highlighted at the end of Chapter 3, virtual space in coin-op videogames can be defined somewhat arbitrarily to meet design goals. *Pac-Man* and the ghosts move at very particular speeds, varying by level, and the same is true for *Bubble Bobble*'s monsters. By contrast, pinball has to work within the natural laws of physics.

Arcade-style games rely on three basic speeds, varying by function:

- Objects that the player controlled directly tended to move very slowly, or in very constrained ways, in relation to the other objects. This slow movement enables precision, as it was often the only way to aim. This tight coupling of the player's

dodging and the player's aiming often also created contradictory urges, since lining up to shoot and lining up to react were sometimes mutually exclusive.

- Objects that the player had to respond to tended to move comparatively slowly. This gave the player a broad window of time in which to react. Common examples include the alien shots in *Space Invaders*, the enemy shots in *Berzerk*, and the missiles in *Missile Command*.
- Objects fired by the player tended to move swiftly, though slowly enough that a player could watch their movement. This made it possible for players to see how much a shot missed by, taking corrective action prior to the next shot (often by repositioning of the slower player object).

In many arcade-style games, whether all digital or primarily mechanical, the player is responsible for shooting targets and reacting to the targets firing back[20]. In pinball shooting is done by timing and position of the ball relative to the flippers, whereas the "targets firing back"–needing to respond in a timely fashion to an incoming projectile–is loosely analogous to handling the ball's return from the upper playfield.[21] Within virtual space, achieving the pattern described above is straightforward, largely a matter of programmer decision. How, though, within the natural laws of physical objects, did pinball achieve these relative speeds to work well for real-time digital input?

The answer lies in the pinball table's angle, and the clear divisions between upper and lower playfield elements. Aside from a few completely vertical playfields, such as *Pickwick* from 1901 (Bueschel 51) or *Little Whirl-Wind* from 1930 (Sharpe 29), and the

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[20] Although *Pac-Man* did not include projectiles, another maze game, *Wizard of Wor* by Midway in 1981, fit the above pattern more closely.

[21] The largely similar core gameplay loop in early brick-and-ball games such as *Breakout* and *Warlords* highlights a slightly more literal connection underlying this analogy.

consistently steeper Spanish tables[22], designers created most pinball tables for a 3.5° to 7.0° incline[23]. This slope is suitable to give the ball a decisive but gentle downward pull. Pinball shots are able to "hang" for a drawn out moment before falling, condensing the uncertain suspense of a pop fly baseball or a basketball three-point shot into table-sized space. This range of angles is also not sufficiently steep to prevent the ball from being thrown upward across it by flipper force. With the targets on the upper playfield, and the flippers on the lower playfield, no matter how other elements were placed on the field the ball could be shot swiftly but would tend to fall back slowly.

The slowness of descent also makes it much easier for a player to see clearly what's happening as the shot makes its way down the table. Even for pre-flipper games, this provided feedback on the player's input, and offered an element of spectacle through its unpredictability.

In terms of delivering the pinball player's shots faster and straighter, flippers were weak when invented but increased in power, industry wide, in the decades that followed. The pinball flippers first used in *Humpty Dumpty* were not powerful enough to throw a ball the full length of a playfield, which was part of the motivation for incorporating six of them (*Tilt*, extras "A Conversation with Steve Kordek" 4:57). A year later, in 1948, Steve Kordek established the convention of placing the primary (often only) flippers at the bottom of the table, including an increase in flipper strength to reach targets higher on the table (Flower, Kurtz 40). Flippers became so popular that they not only appeared on

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[22] Roger Sharpe writes, on p. 117 in *Pinball!*, "The Spanish games… are fast. Very fast. The incline of the cabinets is much steeper than Americans are used to, with short front legs and tall back legs making the machines look like they're falling forward."

[23] Although Kent documents that *Baffle Ball* used a 7° incline (Kent 2), and the later Williams standard was around 6.5° or 7°, measuring the playfield angle of a 1973 Gottlieb *Big Indian* set up as indicated in the manual (so that the bottom edge of the cabinet is level) results in a much more shallow angle, close to 3.5°. The difference presumably is at least partly due to needing the much weaker flippers in the pre-ramp 70's to still reach all areas of the playfield, but also gives older pinball tables a more floaty, almost slow-motion feel compared to more recent games.

virtually all new machines, but were even added to many previously released pinball machines via conversion kits (Ibid.).

Continuing that trend toward higher power flippers, in 1968 for *Hayburners II* the same Steve Kordek introduced 3-inch flippers instead of the then-common 2-inch flippers. The longer flipper gave players higher ball speed, which consumers responded to so positively that other pinball developers rapidly adopted this longer size and increased game pace as the new standard. After *Black Knight* introduced multi-level playfields in 1980, and *Space Shuttle* further popularized ramps in 1984, even stronger pinball flippers were needed to ensure balls had sufficient speed to make it up ramps (4:46 *Tilt*, Extras "Evolution of Pinball").

If an athlete wants to be able to throw farther and more accurately, they not only need to practice, but conditioning and strength-training exercises may also be necessary. For players of arcade-style games, the force and mechanical accuracy are equal across all players, since the work is done primarily through powered mechanisms that are triggered by button presses. Likewise when playing a videogame, the player does not need to be fit enough to tolerate the g-forces of a racecar or spaceship, nor trained in throwing punches or running at full speed between leaping high into the air. In the virtual case the "work" in is just as automated and largely separated from the player's bodily athleticism as when flipping in pinball to shoot a pinball up the table.

Controlled-Play Feedback Loop

In a number of seminal coin-op videogames that let the player fire projectiles, including *Centipede*, *Space Invaders*, and *Galaxian*, the player can only have one shot on screen at a time. Although this was likely a product of implementation, it being much easier at that time to track and reuse a single player projectile, this implementation detail resulted in a non-trivial effect on gameplay: rather than consistent reload time applied between shots, player rate of fire became a function of accuracy. Shots that fail to hit any

targets stay on screen longer, preventing the player from firing another round until that previous one reaches the edge. Hitting targets reliably gives the player a faster reload time than missing. Even worse for the player, while waiting for the shot to leave the screen, opponents in many of these games continue to advance or assault the player with temporary impunity.

This mechanism worked to discourage spamming–firing without any intended target–by rewarding deliberate play. In video arcade games with clusters of enemies, such as *Space Invaders* or *Galaga*, blind fire might work early in a level with many targets live, but as that number decreases it becomes increasingly important to not miss, or else the player is left helpless while waiting for the missed projectile to leave the screen.

Asteroids allows a player to have four shots active at the same time, and bullets expire in less time than it would take for them to leave the screen. However the same pattern described above still applies: players firing as rapidly as possible but missing targets face substantial pauses between bursts, defenseless while those bullets linger before vanishing.

Games with this dynamic provide an even higher rate of fire when shooting targets closest to the player. Since collision between player and enemy tended to cause player death, this provided a reward for risky behavior in coin-op videogames. The dive-bombers in *Galaxian* or an oncoming swarm of nearby rocks in *Asteroids* demonstrate this behavior.

In pinball, when a shot enters an intended channel, such as a ramp or an orbit, with enough velocity to complete the track, the ball gets swiftly, predictably, and often safely returned back to the flippers. By comparison, if a shot misses by a few degrees to the left or right–not enough to hit a different target, but just enough to hit the wall between targets–it rebounds somewhat unpredictably off a round post, requiring the player to scramble to bring the wild ball back under control. This creates potential for a positive feedback loop in the player's favor. When the ball winds up where the player

intends, it becomes easier for the player to make their next shot, creating rallies of smooth, successful hits.

Difficulty Design in Button-Based Games

Many arcade-style games were playable by only one player at a time. In such an arrangement, the longer any one player could tie up the machine on a single payment, the less revenue the machine would generate over a fixed period of time. Coin-op videogame designers found success with the same solution that had worked for decades before with pinball: to make playing time per turn a function of player skill, but to make loss a very quick and decisive event that can occur in a moment of:

(1a.) Lapsed attention
(2a.) Misjudged input timing
(3a.) Failing to recover from losing control

Each of these three different causes for failure can be mapped to mechanisms at a designer's disposal to affect the likelihood of player loss:

(1b.) Distracting the player's attention
(2b.) Overwhelming the player, as with split attention, multitasking, or abrupt changes
(3b.) Increasing the number and severity of ways for the player to lose control, or to tempt the player to take actions that will jeopardize control

Distracting the Player

The first of these three, distracting the player's attention, seems the most unfair and objectionable if done too blatantly, since it's a technique we would consider bad

sportsmanship if done by a human opponent. To maintain a sense of fairness, pinball and coin-op videogames instead tended to err in the opposite direction, using specific features to direct player attention to where it ought to be: flashing before ejecting a ball from a kick-out hole for a pinball machine, or using special animations and colors to help a player locate their videogame avatars on a busy screen.

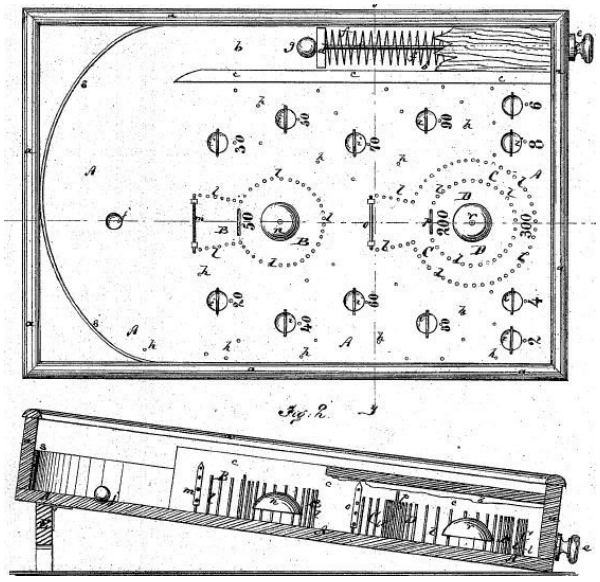

Figure 19 Drawing from Montague Redgrave's patent for *Improvements to Bagatelle*, 1871. Note the use of bells to give audio feedback for scoring difficult shots.

That said, much like a slot machine, part of the appeal of arcade-style machines was in their mesmerizing use of bright, colorful lights and rhythmic tones/bangs. Pinball has used bells for feedback since the parlor bagatelles of the late 1800's, including Montague Redgrave's *Improvements to Bagatelle*. As mentioned in Chapter 3, when electricity was added to coin-op bagatelle games in the 1930's, one of its initial uses in *Contact* was to ring a doorbell-like chime (Sharpe 40). *Flash*, made by Williams in 1979, incorporated flash lamps, small bulbs intended produce intensely bright light in brief bursts to add excitement.

Meanwhile in coin-op videogames, explosions and special effects in *Defender* were created by specialized routines authored by Sam Decker, another programmer working specifically on those features (Kent 119). The color cycling stars in the background of *Galaga* helped give the game a continuous glimmer unmatched by other games at the time (Ibid.). Spectacles created by these features to excite the player also divide attention, making it more difficult to react appropriately.

Overwhelming the Player

One type of challenge common among arcade-style games is requiring the player to track multiple independently moving objects. The player's eyes and concentration can only focus effectively on a single moving object at a time, forcing the player to juggle attention between multiple moving threats. In *Pac-Man* or *Joust*, this effect occurs on account of having multiple enemies on the playfield, each moving more or less independently of the others. In pinball, this challenge took the form of multiball.

Figure 20 *Joust*, showing the players taking on multiple enemies at once. Screenshot taken by quizzley7 of MobyGames.com.

Before multiball became a proper feature integrated into the scoring and objectives in pinball games, it was a feature that players discovered as a side effect of how rounds were implemented on the machines. Each new ball in a modern pinball machine is automatically chambered at the appropriate time. For pinball machines built in most of the 60's and before, a second knob can usually be found immediately beneath the plunger, which the player shoves in to manually load the next ball into the plunger's lane. Nothing about the mechanisms in these early machines prevented players from chambering the next ball before the current ball left play. Michael Scheiss, director of the Pacific Pinball Museum, explained that since the machines are unaware of the extra balls in play there are no scoring advantages to playing this way, but nevertheless younger and more casual players might sometimes launch several balls on-field at once to add excitement and additional chaos (personal conversation, 3 August 2012).

In 1956, Bally's *Balls-A-Poppin* introduced proper multiball to flipper pinball, which started as a reward for hitting a special target hole on the field. Achieving multiball in later 1980's pinball machines, such as *Black Knight* or *Firepower*, consisted of locking balls in various positions on the playfield, then achieving some final goal to release all three. Although the majority of multiball machines, historical as well as modern, have used 3-ball multiball, there are exceptions to this number, for example as a catastrophic novelty the *Apollo 13* pinball game supports 13-ball multiball.

Tempting Loss of Control

Designers of both pinball and coin-op videogames specifically incentivize players to engage in risky play, or sometimes penalize them with additional dangers if a player seems to be playing too slowly or methodically. One of the most common ways to get a player to take unnecessary risks is to make them rush if they want optional rewards. Both pinball and coin-op videogames have a history of doing this to players.

The four banks of three drop targets used in *Black Knight* are one example of this design choice. Once the ball strikes any of the three targets in a bank, a loud ticking timer begins, and if the player takes too long to hit the other two targets in the same bank, the dropped target(s) in that bank will pop back up. Clearing all three targets in one bank before that timer completes enables the player to use the game's Magna-Save feature, letting the player keep the ball in play longer. Completing a pair of drop target banks three times each lights an Extra Ball (pinball 1-up) opportunity elsewhere on the field. Scrambling to hit these banks of targets before their individual timers reset increases the likelihood of losing ball control and ending the current round.

Whereas targets in pinball can pop below the playfield to vanish, or light to indicate special scoring opportunities, in videogames objects are able to simply disappear and appear. Rather than rushing the player with timed drop targets, a coin-op videogame like *Bubble Bobble* instead dangled power-ups at out of the way locations in the levels, which flickered and vanished if not reached quickly enough. As in the pinball case, the temporary nature of these incentives can compel the player to take chances during play that they otherwise would have no reason to attempt.

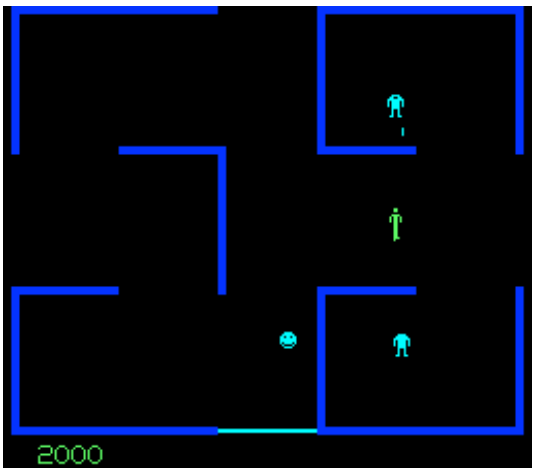

Figure 21 *Berzerk*, with Dr. Otto bottom-middle. Image from Arcade-Museum.com.

Bubble Bobble includes another design element used in various videogames to rush the player. If a player takes too long to complete a level, an invincible ghost appears and chases after the player, moving through walls, going away only upon completion of the level or death of that player. This ghost followed the same pattern used for Dr. Otto in Atari's *Berzerk* in 1980, who was also an invulnerable enemy able to move through walls in pursuit of the dallying player. In-between, in 1982, *Joust* introduced a pterodactyl enemy for this same purpose, although strictly speaking the pterodactyl was not completely invincible but instead very difficult to defeat. Players discovering this fact found that the pterodactyl became still another temptation to take engage in risky play; by waiting for the creature to spawn with the intent of defeating it, more points could be earned.

Anticipation Loop for Continuous Motion

Continuity in space, combined with behavior defined by fundamental laws (physical laws for pinball, or analogously collision handling for coin-op videogames), makes it possible for players to interpolate and extrapolate their prior knowledge to form expectations about new actions. In other words, having played or practiced a real-time game, players have some idea about what will result if an action is taken slightly earlier or slightly later, about how a ball ought to bounce given its trajectory, or about what enemy AI is likely to do next given its current position(s).

In baseball, each high fly is immediately followed by anticipation over whether the ball will make it past the fence, be caught, or make it back to a base in time to tag the player out. In basketball, a three pointer seems to hang in the air, creating a moment of anticipation over whether the shot will make it. Pinball and many early coin-op videogames are filled with this type of anticipation, but taking place on a more rapid timescale and occurring many times each minute.

In pinball, beyond the most casual manner of merely hitting the ball randomly, each hit is followed by a moment of hope and anticipation for whether it will hit its intended target. In *Space Invaders* and other games with unguided projectiles, or in a game like *Breakout* that presents one or more ball in play, a similar hope and relief takes place over whether each shot or deflection will connect with the target intended by the player.

CHAPTER 5

HOOK-ONLY FICTION

Stuck in the Middle

Aristotle divided story into a beginning, middle, and end. Respectively, these refer to the set up of the conflict, how characters respond to the conflict, and the resolution of that conflict. Although it's common for modern console and PC videogames to reflect all three of these elements, carrying a player from introduction of the problem, through confrontation and toward final resolution, gameplay in early arcade games has tended to concentrate almost exclusively on the middle, with an implied or exceedingly brisk beginning, and no final resolution.

This arrangement is a product partly of technological limitations, though is mostly–as is evidence by continuation of this pattern into modern arcade games–a product of the revenue model and context in which these games are available to the public. An ending marking final resolution of the conflict is undesirable; as long as the conflict remains the player can continue spending change. Without a carnival barker present to call people in and explain the scenario, the game's context needs to be instantly understandable. A sufficiently obvious setup of conflict can help invite a potential player from across the room. A long-winded exposition or non-action phase at the start of each round would lengthen gameplay time, lowering revenues, and becoming repetitive for players on repeat plays.

One way that console and home PC videogames have encompassed larger, longer, more complete stories is through the widespread adoption of methods to resume from the last point of progress reached. On such platforms, it's typical for every player to have their own save file, or in the mid/late-80's with console games like *Kid Icarus* and *Mega*

Man, each player recording their personal passwords in order to later skip past what they already completed. These mechanisms enabled designers to create a series of escalating challenges, intertwined with a progression of story events and character advancement, without needing to require that the player replay past territory nor watch and hear exposition over again.

Arcade-style games have no knowledge of the player's past experiences. If the game depicted story with a slow, moving introductory sequence, watching that sequence would need to become a part of every round. *Donkey Kong* opens with an approximately 13 second sequence of Donkey Kong climbing to the top of the screen then jumping to bend the stage's platforms, which as arcade exposition goes was quite elaborate for 1981. 6 years later for *Double Dragon*, a game with far more graphical content at much higher quality, only half that much time was given to the introductory sequence showing some of the game's bosses hitting and kidnapping Marian.

The way that arcade-style games utilize fictional elements is more akin to the hook in a song or piece of writing–it aims to draw attention on the rest of the work. The story in such arcade-style games usually does not progress beyond that point. If we consider *Space Invaders*, *Pac-Man,* or *Asteroids*, the core play in such games is about fighting aliens, escaping ghosts, or dodging and destroying asteroids, not about winning (which is impossible) nor losing (which is inevitable, and as such loses much of its power), but is instead about the present tense verbs locked into that drawn out period of conflict. In terms of fiction, for arcade games the imagery and theme serve to instantly establish the conflict, while the gameplay[24] is about working toward an unreachable final resolution.

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[24] Beginning around the mid-80's, there have been prominent exceptions to this model in arcades: *Dragon's Lair* (1983), *Double Dragon* (1987), and *Ninja Gaiden* (1988) are all counter-examples that followed the linear level progression toward final conclusion, a form now widely associated with console videogames.

Am I the Ball?

Go, billiards, Poker, bowling, and baseball are accepted as games in which the only characters are the players, the only plot progression is how the scoring and advantage fluctuate throughout play, and the elements involved are not skinned with metaphorical clues (making a goal is just a way to increase the score–it's not the slaying of a dragon, the acquisition of lost treasure, or a betrayal within the royal family).

Prior to the 1930's, pinball games–at that time still mostly resembling parlor bagatelle due to lack of flippers–were similar in their level of abstraction. The game presented itself as nothing more than steel ball rolling on a decorated wooden board, and scoring events were numerical, either adding a fixed number to the total score or indicating a multiplier on other points scored. However unlike traditional abstract games, which featured standardized layouts, the novelty business required different playfield arrangements and features to keep the games feeling new. Churning out new table designs was also important because of the revenue structure within the amusement industry at the time: game creators made money up front from each table sold, but they did not receive money directly from consumers (*Tilt*, extras, "Pinball Industry Economics" 0:13), which instead wound up split between the machine owners/maintainers and locations. If manufacturers could not find a way to obsolete the golden goose that they sold their clients the previous year, they could not profit from repeat business.

Pinball designer Pat Lawlor, in another interview for *Tilt* (10:22), offers the 1986 game *High Speed* by Steve Ritchie as among the first pinball games to effectively "tell a story."[25]

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[25] According to designer Steve Ritchie, the story is roughly autobiographical. "It was based on a true story. I was actually chased by the cops at 146 mph in my 1979 Porsche 928" (Williams '*High Speed*').

> A pinball machine, say circa 1968, was a game that was a much slower game. The object of those games, while it was to score high, was almost universally to complete a set of targets, to do something in some order– something along those lines. Pinball from approximately 1986 on… had the ability to tell a story. I peg it as being the game *High Speed*... [Steve Ritchie and Larry DeMar] together they created a game and everybody in the world instantly knew what they were supposed to do when they walked up to the game. It was really simple: change a stoplight from green to red, then run the light and get away from the police. The game told a story. It was a simple story, but it told a story. The game was an enormous success... Pinball changed, starting then, into, "Why am I here, what am I doing, what story is the game telling me."

Lawlor's distinction identifies that the majority of postwar pinball games (those prior to 1986) did not aim to present their themes in a narratively coherent way. It also reveals that even with the introduction of story sequence into pinball gameplay design, the ball was not representative of a single fictional element; while in the act of running the red light and getting away from the police suggest the ball conceptually represents the car, in the first step, changing the stoplight from green to red, it's unclear what the ball would be analogous to. Abstract, traditional playfield actions also take place that bear no relationship to the game's fiction. Surely, when the ball is accumulating points banging around between the upper playfield bumpers, players are not meant to imagine that event is a drawn-out automotive crash.

In another interview (*Tilt* extras "Designing a Pinball Machine" 3:35), pinball designer George Gomez recalled a story of a new businessperson at Williams asking another designer, "So, Steve [Ritchie], I'm trying to understand... Am I the ball?" As Gomez goes on to clarify, pinball, even with the more elaborate and sophisticated themes in the 80's and beyond, is still an inherently abstract game. Depending upon the particular game and elements being struck or passed, the pinball might conceptually be thought of as any number of things, however for the vast majority of playfield interactions it's

simply a pinball, in much the same way as a baseball is just a baseball and a bowling ball is just a bowling ball.

Lawlor does not address the 18 years in-between 1968 and 1986. Those 18 years cover the same time period that took videogames from research labs to a worldwide industry. As with many conceptual and technical innovations now taken for granted in arcade-style games, this change did not happen overnight from an isolated stroke of genius. The transition from highly abstracted sport metaphors to hook-only fiction came about at the tail end of a larger trend in the evolution of arcade games, beginning with some of the breakthrough titles that distinguished pinball as a viable industry.

Early Pinball Applications of Theme

David Gottlieb distinguished his 1931 game *Baffle Ball* from earlier parlor bagatelle designs partly by using a table colorfully decorated to resemble a baseball diamond. The game does not feature any detailed depictions of baseball players, baseballs, or verbal allusions to baseball concepts (i.e. there is no “Home Run” nor “Second Base” scoring pocket). However the scoring pockets are positioned roughly where bases are positioned at the four corner of the playfield diamond, all atop a grass-green background. *Baffle Ball* is not a game *about* baseball. It is in no way, even in the most approximate sense, any sort of baseball simulator. It instead implies association with the sport by borrowing iconography, for recognizability, albeit it does so without using either scoring or goal metaphors from baseball.

Figure 22 The playfield of *Baffle Ball* alludes visually to a baseball field, however the gameplay had no connection to baseball scoring. Note that the cup at first base is even worth more points than the cup at third. Photo by Harold Balde (Gottlieb '*Baffle Ball*').

Only a year later, in 1932, Gottlieb released *Play-Boy*, a game basing its playfield design on a deck of playing cards–except unlike *Baffle Ball*, in this case the scoring was based exactly on the significance of cards and hands in blackjack or poker. Besides appealing to potential players that have prior experience and association with cards, this also instantly conveyed a complex scoring system that, without card labels, would be much too complicated and arbitrary to explain on an instruction cart or playfield labels. This reduced the amount of material for players to learn by trial and error, reading instructions, or peer explanation.

This process of appropriating visuals and approximate scoring models from outside games, to differentiate new tables with novel visuals and never-before-seen scoring features, continued throughout the 30's. When *Bolo* was released in 1936 as the first game to score mid-field collisions (in prior games the score was determined solely by where each ball's movement ended), the mid-field bumpers were designed to resemble bowling pins. In keeping with the rules applied to the traditional game of bowling, the electronics were wired to score each pin only once between the two balls per play.

Figure 23 References to existing games helped clarify rules. Photo by Wayne Namerow (Gottlieb '*Play-Boy*').

Theme in Postwar Pinball

Early postwar pinball games also borrowed depictions and scoring logic from non-pinball games, though the decades of competition leading up to that point led to an arms race in playfield decoration. To set newer games apart from older models and competitor's products, complex mechanical toys began to complement the playfield imagery. *Knock Out* from 1950, for example, prominently featured two toy boxers in the middle of the ring. Thin wire and articulated joints enabled the fighters to mechanically exchange blows, even "knocking the opponent down" in response to player achievements on the field.

Still, however, note that *Knock Out* was not a boxing game. It did not feature boxing-like interactions, despite using boxing-like depictions and associations. Note, too, that all of these examples so far have been of pinball emulating some other abstract, fictionless game: baseball, playing cards, bowling, and boxing. Despite these

metaphorical and decorative uses of non-pinball games, the games are not attempts to recreate those activities.

For the next two decades, the ongoing search for novelty and differentiated products led to many themes that were neither references to other games, nor references to stories. *Central Park* in 1966 depicted a pleasant day in New York City's park. *Aztec* from 1976 presents a mixture of blocky symbols, cartoony representations of Aztec Indians, and a glowing temple in the distance. The *Dimension* pinball table, released in 1971, utilized unspecific sci-fi imagery of planetoids, starbursts, and a generic superhero flying through a wormhole. The only words on the playfield at this time were still purely functional and abstract: "500 points or 3000 when lit," "10,000 advance bonus," or "target value." *Aztec* included 3 different sets of letter lights on the table to spell out words through different combinations of actions, but each one of those words is A-Z-T-E-C, providing no additional context or meaning about the concept.

In 1981, *Black Hole*'s playfield was still littered primarily with functional and unimaginative words: Captive Hole, Special, Extra Ball, and Bonus Multiplier. However the table also included a few non-scoring words on the field to provide in-fiction context for the game's central special feature: entrance to a hard-to-escape lower playfield via a "Gravity Tunnel", with the exit labeled "Re-Entry." Although using this feature in the game was likely inspired by the game's theme (or perhaps even the other way around), it still serves as more of a crude metaphor than as a representation of a black hole.

Nor, when pinball games covered knockoff properties (for example *Dragonette* in 1954 based on *Dragnet*, *F-14 Tomcat* released in 1987 shortly after the film *Top Gun*, or the 1979 *Space Invaders* machine showing an unlicensed imitation Giger alien on the backglass) and licensed properties (ex. *Evel Knievel* in 1976, *Charlie's Angels* or *Harlem Globe Trotters* in 1978), were those games attempts to make the player feel like they were solving cases, piloting a jet fighter, escaping aliens, doing stunts, fighting villains, or performing basketball tricks. The symbolism and artwork on the board might borrow

liberally from the subject matter. In many cases toy models and musical stings might be employed to reinforce the theme, and general pacing could be inspired by it. A pinball game about jet fighters, for example, introduced an entirely new high-powered Jagov Kicker playfield part to achieve higher ball speed (Williams '*F-14 Tomcat*'), while a driving-themed game added a magnetic accelerator to run the ball in laps (Williams '*The Getaway: High Speed II*').

Figure 24 *Dragonette* was an unlicensed play on the *Dragnet* IP. Photo by Chris DeLeon, taken with permission at the Pacific Pinball Museum.

This use of physical games and stories as themes, for sake of appeal by association, distinction from competitor's (or earlier) products, and occasionally for efficient conveyance of otherwise complex goals and scoring, provides a very specific perspective on the application of fiction that we can extend to a question about the earliest coin-op videogames. To what degree was *Space Invaders* a crude simulation of

flying a spaceship, and to what degree was *Missile Command* about the activity of shooting down missiles, as opposed to these being otherwise inaccessibly abstract games that employed these fictions as a device for appeal, differentiation, and efficiently relating the goals?

Figure 25 *Missile Command*. Photo by Garry R., via pinballrebel.com.

Theme in Golden Age Coin-op Videogames Games

When coin-op videogames entered and gradually took over arcades beginning in the 70's and 80's, they fit smoothly into the same market niche then held for decades by pinball. In every location the general scenario that the machine had to succeed in was the same: attract customers from a distance then present them with a challenge and concept that they can easily figure out. The best of these machines drove players to repeat attempts.

Succeeding against the same challenges faced by pinball machines required attention to many of the same qualities in the fiction: trivial understandability (hook-only fiction), ease of replay (no lengthy introduction), lack of an ending, and either novelty (standing out by being highly unlike anything else made by that time) or knock-off

recognizability (riding the immediate market attention of another medium's more successful works). The narratives in early coin-op videogames, no less than the pinball themes, are mostly frozen in time.

In the same way that the earliest pinball games were unabashedly abstract–treating the ball as nothing more than a scoring implement, and employing decoration without fiction–in the realm of early coin-op videogames titles like *Breakout*, *Marble Madness*, and *Qix* made their mark in game history while presenting largely decontextualized risks and scoring activities. It's also worth noting, under the subject of theme, that *Breakout* had a background theme of breaking out of prison, which is not widely remembered by consumers but played an important role in giving the cabinet design a sense of character and motivation not reflected within the game itself:

Figure 26 Cabinet art conveyed story context for *Breakout* in a completely static way, which the gameplay hardly addressed. This is consistent with the functions of backglass and cabinet art for pinball. Image from Arcade-Museum.com.

Similar to the pinball games that thematically borrowed from then-popular and well-marketed intellectual properties, videogames employed the same device to great success. Although *King Kong* was originally released in 1933, a remake was released in 1976, only five years prior to *Donkey Kong* (Kent 179). The gorilla climbing a skyscraper with the abducted girlfriend, the use of the word Kong, and an attempt by Universal Studios to license a *Donkey Kong* knock-off as a *King Kong* game came to a court case, which in the end Nintendo won on account of confusion over ownership and public domain status of the original character from 1933 (Ibid.).

Tomohiro Nishikado, the lead developer of *Space Invaders*, admitted in multiple interviews ("Classic GI: Space Invaders"; "Nishikado-San Speaks") that his decision to change from a military to space theme came directly from seeing a *Star Wars* article (*Star Wars: A New Hope* was released in 1977, *Space Invaders* in 1978). *Asteroids* and *Galaxian* released the next year in 1979, *Defender* in 1980, and *Galaxian*'s more famous sequel *Galaga* in 1981. Although *Defender* developer Eugene Jarvis explained that setting games in space was partly motivated by the strict technological constraints (Kent 118), and even though this genre worked well to establish urgency and enable imaginative spatial interactions, the runaway space hype achieved around this time by the original *Star Wars* trilogy (*Empire Strikes Back* came out in 1980, and *Return of the Jedi* in 1983) cannot be overlooked.

In appealing to novelty and interaction videogames were able to take advantage of the digital medium's superior versatility. Early coin-op videogames games like *BurgerTime*, *Bubble Bobble*, *Joust*, *Centipede*, *Q*Bert, Frogger, Super Mario Bros*, and *Pac-Man* present gameplay universes in which the narrative concepts and characters may seem nonsensical, but the vastly different themes helped differentiate these projects from the competition at the time.

Freedom in object representation created opportunities for these mishmash intellectual properties to fit specific interaction needs. One key example of this is the

selection of coins as collectibles for *Mario*, for no better-contextualized reason than wanting to present something that the player would immediately know to collect. As translated for Kotaku by Brian Ashcraft,[26] Shigeru Miyamoto explained that when he was working on *Mario Bros*: "Thus, when we were thinking about something that anybody would look at and go 'I definitely want that!', we thought, 'Yep, it's gotta be money.'" The same can be said for why *Pac-Man* needs to collect bells and keys (the fruit items at least fit within Iwatani's vision of a game about eating (Kent 114)). Significant scoring actions like these that take place within the game but do not fit within the overall theme share the relationship between the pinball and targets scattered about the table. Mario does not need the money, and Pac-Man does not need the keys, any more than the pinball needs collisions. In all of these cases the target exists only because the player desires extra lives and higher scores. In the same way that Poker cards and baseball diamonds provided some contextualized meaning for coin-op bagatelle games in the 1930's and 1940's, alien spaceships, spiders, and spiky monsters provided coin-op videogame players with recognizable metaphors hinting at what to expect in terms of behavior and interaction.

When Dave Theurer's team lead at Atari, Steve Calfee, called him in for his next assignment, Calfee asked Theurer, "…to explore the idea of the U.S. being invaded by the USSR… to have this radar screen that shows missiles coming in" (Kent 112). Theurer knew it was a promising concept for the time period. "It was so relevant–that was in the middle of the cold war." *Missile Command* has no victory ending, and though it can be played for as long as the player can sustain performance, every round of play inevitably ends with losing every American city. In spite of the inevitable Soviet victory ending every match, the game's US revenues might have told a very different story if the game were widely perceived as being about what's technically depicted, US cities succumbing

[26] The original Japanese interview, from which Ashcraft found and translated the excerpt, is available online at: http://www.nintendo.co.jp/n10/interview/mario25th/vol5/index6.html

to Soviet nuclear strike, as opposed to the active in-present concept, US cities defending themselves from Soviet nuclear strike. If the player accepted the loss as final, that would also not facilitate nearly so many replay payments as maintaining a sense of endless battle.

By contrast, in the 2010 home console videogame *Red Dead Redemption*, when the player's character is defeated near the end of the game the death is contextualized within the story. Death in *Missile Command*–or in *Space Invaders*, or ball loss in any pinball machine–is just as inevitable as the death at the end of *RDR*. The difference is that death in arcade-style games feels like something that should not happen, and thus should be staved off despite its unavoidability, serving non-narratively as a taunt to the player to retry. Death in a game fundamentally designed around consecutive replay is necessarily not final; it's only a hiccup between more playing. In *RDR* the player is not challenged to replay the scene in an effort to survive or prolong the situation more successfully, since the event takes place as a plot device beyond the player's control.

When the player's character dies in *RDR* before that plot event, during standard gunfight gameplay, the recovery experience is more like that of an arcade-style videogame. The player gets thrown abruptly back into the game world to retry whatever effort failed, forfeiting a bit of progress but otherwise not acknowledging the death. In this way modern console videogames might be framed as a progression of arcade-style experiences, in which surviving each repeatable one-hook/theme challenge unlocks the next. Whatever course of action advances the player along that progression distinguishes plot-death from non-plot death; deaths early in the game prevent advancement to the next story beat, however to advance further into the ending the player has to accept their character's defeat. For games with inevitable death but without a plot to advance, every death becomes a non-plot event.

The in-game narrator in *Prince of Persia: Sands of Time* from 2005 declares after each death, before respawn, "No, that's not how it happened…" which sums the attitude

of non-plot deaths earlier in *RDR* and the round terminating events in arcade-style games. The Soviets do not win in *Missile Command*, the aliens do not win in *Space Invaders*, and the police do not win in the pinball game *High Speed*. Such loss is not meant to be accepted, but is merely a temporary embarrassment until the next attempt.

CHAPTER 6

CONCLUSIONS AND APPLICATIONS

The Literal Intersection of Pinball and Videogames

Although I have focused on the parallels and influences between the pinball industry and videogames, these are deeply different games. Nowhere do the differences stand out more fully than the literal intersection between pinball and videogames. From the videogame side, this means pinball simulation; from the pinball side, this means pinball machines that intermix videogame gameplay, including the Pinball 2000 series in the late 90's, in 1982 both Bally's *Baby Pac-Man* and Gottlieb's *Caveman*, and in 1984 Bally Midway's[27] *Granny and the Gators*.

Pinball Videogames

As early as Atari's standalone *Video Pinball* console in 1978, videogames have aimed to approximately simulate the experience of playing pinball. *Pin*Bot* and *High Speed* on NES in 1990 and 1991 respectively are among the earliest official efforts to reproduce designs from real machines. *3D Pinball for Windows - Space Cadet*, included with numerous versions of *Windows* beginning with *Microsoft Plus! 95*, is the most common exposure my peers have to pinball. More recently, *Pinball Arcade* by FarSight came to market in early 2012 with licensed simulations of physical pinball tables made by Bally, Gottlieb, Williams, and Stern.

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[27] "Bally Midway" is not a typo; between the creation of *Baby Pac-Man* and the creation of *Granny and the Gators* a business deal turned Bally into Bally Midway.

There are, even in the most accurate simulations, substantial differences between real pinball and pinball videogames. Physicality, while obviously present in pinball and lacking in videogames, affects the experience in non-obvious ways. Real replay knockers are startlingly loud, real lights can be significantly brighter, and real sounds from rolling and mechanical changes are spatially located. Applying body English to a real machine involves full-body coordination and offers a much finer range of control over force, angle, and timing than the nudge input options possible for pinball videogames. Occasionally the real physics of spin and friction cause peculiar ball motions that might seem unrealistic or buggy in a simulation–for example the ball briefly rolling upward after a drop, or popping up against the glass–though when these events happen on a physical table there's no room to question the realism. Flippers in most pinball videogames rise completely at each press, and fall completely at each release, an approximation that prevents some of the advanced flipper techniques from real pinball that depend upon briefly applying or releasing flipper force for a flick (Elwin 10:42) or tap (Elwin 26:30) action.

The other difference is one of our expectations with either medium. When players notice there is a moving mechanical monkey striking a bell in the backglass of a pinball machine from 1966, it seems surprising and delightful (Gottlieb, "*Central Park*"). Seeing inanimate objects appear to come to life is not a part of ordinary daily experience. 1990's pinball games took this toy spectacle to another level, with a talking dummy head (*Funhouse*), a rumbling castle (*Medieval Madness*), and a "gripping"/magnetic hand (*Addams Family*). In digital representations of space for videogames, by contrast, it's common to see animated characters jump over one another's heads, monsters eat one another, and a hail of projectiles resulting in spectacular explosions. When *Pinball Hall of Fame: The Williams Collection* on PlayStation 3 accurately depicts the talking dummy head from *Funhouse* or the castle collapse (noisy, rapid shake) in *Medieval Madness*, the effect is not very impressive compared to other cinematic imagery and grand events

typically depicted in other PlayStation 3 games.

Figure 27 When the real dummy Rudy in *Funhouse* opens and closes its eyes and mouth, it's a little surprising and unsettling. When those crude mechanical movements are depicted accurately on-screen for a videogame, it looks like bad animation.

Videogame Pinball

In 1982, two arcade machines were created that combined on-screen videogame play with physical pinball action: *Caveman* by Gottlieb and *Baby Pac-Man* by Bally. In both games, scoring events on the pinball playfield improved player circumstances for the next video play, although the games played in alternation. A small joystick on the lockbar (the metal spacer on top-front of the machine, between the flipper buttons) controlled the player's avatar through a maze displayed on television monitor at the rear of the machine. These forced combinations of game types meant that they appealed only to players that were fans of both pinball and videogames, but not fans of only pinball or only videogames. Making room for the monitor while keeping down machine costs also

resulted in smaller, simpler pinball playfields, and games less impressive than those designed for standalone cabinets. Although this exact pattern did not catch on, echoes of this alternating style returned as a common feature called video mode on dot matrix displays, beginning with *Terminator 2*. Dot matrix play was even shorter and simpler than that of *Baby Pac-Man* or *Caveman*, and controlled by the flipper action buttons rather than involving an additional joystick.

Figure 28 A videogame built into a pinball machine. (Gottlieb '*Caveman*')

Less than a few years before the Williams pinball division closed, George Gomez and his fellow engineers developed the Pinball 2000 platform, which took a different approach to combining pinball and videogames. Gomez combined pure pinball gameplay,

using flippers the entire sessions for ball control and shooting, with an upper playfield consisting primarily of superimposed screen animations. The platform utilized a combining mirror, and technology pioneered by Disney (*Tilt*, Expo Speech 17:08) to create a nearly opaque reflection over obscured physical targets on the playfield. This made it possible for players to shoot the pinball against what appeared to be an animated UFO on the playfield, causing it to virtually explode. In 1999, *Revenge From Mars* was the first game to use this platform, with *Star Wars Episode I* following later that year.

Figure 29 *Star Wars Episode I*, showing the reflection of the top-mounted monitor on the combining mirror over the rear/upper playfield. Photo by Allen Shope.

Unfortunately, by the late 1990's, the arcade industry as a whole was facing economic difficulty. Less than a year after the released of Pinball 2000 games, Williams closed their pinball division, putting an end to the experiment. Stern, the only pinball manufacturer remaining in business at that time and for most of the following decade, has kept costs especially low to stay in business at lower volume, which has lately put a limit on further explorations into the combination of physical pinball and videogames.

However one very recent development in this area, for which it is too early to tell how it will be used or how players will respond, is the P^3 platform, which integrates a full LCD screen into the playfield and is capable of tracking ball movement in real-time (Stellenberg).

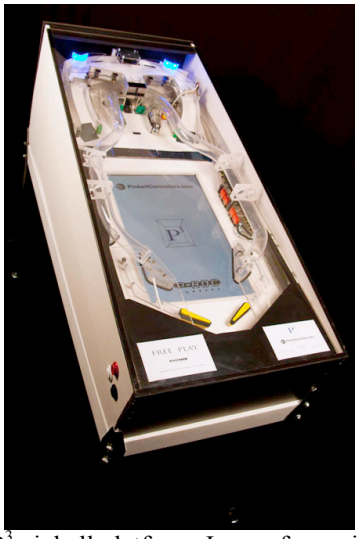

Figure 30 The P^3 pinball platform. Image from pinballnews.com.

The Conceptual Intersection

As I have attempted to show throughout this thesis, however, the similarities, whether from designer influence or convergent evolution, are of greater utility than the differences and incompatibilities. Understanding the historical parallels between these mediums helps call attention to what might otherwise be assumed unique to either. This approach also reveals past precedents for ideas that mistakenly seem new, having been derived independently decades later by a generation of new designers looking to achieve high replay value and high accessibility with comparatively little content. Comparison between the experiences provided by pinball and videogames can also provide new ways to frame today's game design challenges.

Rethinking What's Unique to Computerized Games

One benefit of investigating pinball as a category of games more similar to classic coin-op videogames is that it provides another reference point for researchers to distinguish which qualities observed of videogames are or are not uniquely digital. Consideration for button-mediated real-time spatial gameplay tends to assume that the medium in question is videogames, but physical analogs like pinball give a non-digital frame of reference.

In *There is No Magic Circle: On the Difference Between Computer Games and Traditional Games*, Michael Liebe highlights that within computer games, the automatic enforcement of rules avoids the player needing to willingly accept and play along with the game's constraints. So long as the player can understand how to properly operate the input, the player can play without knowing the rules, and may be able to deduce the rules through feedback provided to the attempted interactions. This pattern is presented in contrast to the experience typical of non-computer games, in which players need to learn the rules in order to play, and consciously abide by those rules during play.

However, while Liebe's paper aims to distinguish computer games from non-computer games, this same observation fits the gameplay of pinball. Although modern solid state pinball machines are partly computerized games, historical electromechanical games (pre-1975) and, even more so, purely mechanical games (early 1930's and before) do not fit nearly as well under the computer game label, either conceptually or technically. The 1933 Chicago World's Fair game *Jig-Saw*, a purely mechanical pre-flippers game, challenged the player to complete a puzzle on the board by landing balls in certain holes, but the logic correlating holes to rows of pieces to flip was mechanically embedded in piano wire. Within a round or two, players could stumble into seeing the pattern in its operation, and the adherence to that pattern does not derive from player understanding or willful acceptance.

Figure 31 *Jig-Saw*. Image by Russ Jensen.

Nor are these types of distinctions necessarily unique to videogames and pinball. Other real-time spatial games played through button mediation are abound, from *Crossfire* to *Hungry Hungry Hippos* and Bally's *Spinner*. My hope is that by calling attention to pinball as a game with deep similarities to coin-op videoarcade games, another bridge (though not the first nor only) may be established from digital game studies into other mechanical and electromechanical games.

Reemergence of Arcade-Style

With their introduction of the App Store in July 2008, Apple introduced a new niche for videogame developers to reach players: smaller games, more cheaply produced, and sold for a much lower price point, often as low as $0.99. Up to that point, the market standard prices for videogames were $50-$60 for boxed retail or $15-$20 for

downloadable casual games. Those higher price points enabled developers to create the high-content, long-play games found to be more popular over decades of console and home PC videogame sales. The new lower price point demanded a change in thinking. Meanwhile, it was unclear whether the form factor of mobile phones would even be conducive to long-play games.

Then came *Trism*, a single-screen game, and one of the App Store's early success stories. What graphics appeared in the game were polished, however overall there was not much content in the game by 2008 standards. A year later, I co-developed *Topple* with John Nesky for publisher ngmoco, a simple physics game designed to be played in short sessions. Adam Saltsman released *Canabalt* the next year, establishing an entire subgenre of platforming games in which the player's only interaction is through a single button.

Each of these videogames involves numerous features and qualities quite unlike old arcade videogames. *Trism* used device orientation derived from accelerometer readings. *Topple* requires touchscreen input. *Canabalt* scrolls horizontally and vertically over a large, procedurally generated space. However each, like many other low-cost iPhone games, inadvertently rediscovered and incorporated elements that were common practice among arcade-style games. Business models and play context once again conspired to favor high replay derived from low content.

The other aspect central to arcade-style game design, high accessibility, also plays a clear role in many smartphone games, but reemerged earlier during the casual games movement beginning in the mid-2000's. PopCap's *Peggle*, released in 2007, has a lot of content by 2012 standards for casual games, however at the time of its release was unusual as a commercially significant PC title not pushing the limitations of 3D graphics cards. Its core gameplay bears a clear similarity to parlor bagatelle, or perhaps more appropriately an early pre-flipper game with passive electronic scoring like *Bumper*.

Figure 32 *Peggle*, by PopCap.

In these cases where casual and mobile games rediscovered what made the designs from arcade-style games successful, the relation is not limited to gameplay. In fiction, too, some prominent games in these categories also abandoned complex narrative in favor of hook-only fiction. *Peggle* does not so much have a story as it has a set of pleasing characters, each with a themed set of art. Adam Saltsman, in discussing *Canabalt*, makes clear that his game's fiction is frozen in an unchanging moment, rather than providing an unraveling narrative:

> "...the emotion or feeling is just supposed to be that middle of action movie action scene but extended and interactive. I think that really sums up the game, that's as deep as the game gets in a lot of ways. You are a guy jumping through windows, and that's pretty awesome." (Swirsky 1:40)

Designing Around Asymmetric Timing for Initiative vs. Response

Early in chapter 2, I highlighted that in arcade-style games, obvious asymmetry in timing was common. Action from the player, expressed via digital button input, tended to

be nearly instantaneous, or just slow enough for its resulting path to be observed. Action against the player, coming from the machine, tended to be much slower. This pattern persists well beyond the arcades in single player console videogames. *GoldenEye 007* on Nintendo 64 exhibits this approach by having enemies animate unnaturally slowly to assume firing posture, giving the player a window of time to react and, via the instantaneous result of the digital trigger, stop the enemy from having a chance to fire.

Shifts toward multiplayer as the primary mode and realism in single player have disrupted and largely lost this pattern of play. Designing for immediate input but slowed down feedback presents an inherent problem in design for real-time games that build single player experience as an extension of multiplayer–and thus symmetric–functionality. The use of AI bots to fill roles otherwise intended for human players, a practice popular shortly after and around the release of *Quake 3* in 1999, removes the aspect of delay providing spatial and temporal clues about impending action. Meanwhile in console shooters like *Modern Warfare 2*, which strive for cinematic photorealism, partially abstracted contrivances like slowly raising a weapon to fire or shooting projectiles that can be dodged by the player would be disruptive to the game's authenticity and believability. This was not always the case for first-person shooters; in id Software's *Doom* the player's main weapons covered distance instantaneously, but most medium and high level enemies up until the final boss fired projectiles that the player had a chance to dodge. Other types of gameplay patterns have emerged within the first person shooting genre, built around regenerating health and cover-based combat, but having a more clearly defined classic approach to contrast these newer gameplay models against can help us better recognize and make sense of how games have changed.

In *Street Fighter II*, designers employed a practice-based compromise that satisfied both attacker and defender. How quickly special moves can be performed is a matter of how rapidly fixed sequences of button and joystick movements can be executed. The result of that sequence is still a discrete move, all or nothing in its

performance, area of effect, and damage. For the player throwing fireballs or performing jumping uppercuts this maintains a sensation of performing the move as quickly as possible, while simultaneously creating a window of time for the opponent to interrupt the move.

Instead of employing button and joystick sequences, the designers could have provided extra buttons for each player to promptly and consistently trigger each character's special moves. If the sequences only existed to accommodate lack of buttons, there are countless shorter, simpler, and easier sequences or combinations that might have been used. In that case the same commands might as well be used for every character (this is largely the case for Nintendo's *Super Smash Bros*). Either approach could have fully addressed the offensive player's preference for immediate response to input, however this would have removed the defender's window for preventative counteraction. *Super Smash Brothers*, with its cartoony character representations, provided the window for response by employing unrealistically slow animations between move start and moment of impact, however for the martial arts focused *Street Fighter II* this approach might make the fighters appear incapable.

The inefficient delay, the clumsiness in executing special moves, is there by design. The power and range of each move is offset by the risk of attempting but failing to accomplish the attack, contributing to the strategy, excitement, and unpredictability of head-to-head matches. Projectile attacks aside, in which case the gap between action (release of the ball) and opportunity for counter (time in flight), much of the struggle consists of players preventing the other from completing their intended input sequences for actions.

Issues Inherent to Motion Control

When the Wii successfully brought accelerometer-based motion controls to market in 2006, in particular to audiences that previously hadn't been playing many

videogames, consumers were excited by the potential for entirely new videogame experiences. The realization of that potential in the half decade since has been a bumpy ride, and as game designer Holden Link explains in *Why I Can't Finish Skyward Sword*, even the first party developers continue to face substantial design challenges in translating genres that originated with button-based play into games incorporating motion control. One potential source for this difficulty is that, having largely taken button-based control for granted as the primary action input over the past 30+ years, as a community of developers we have not adequately dissected the implications of button-based gameplay to understand how motion controls fundamentally differ.

An advantage outlined earlier is that the near instantaneous expression of intention, within 150 milliseconds (Polin and Rain 22), decreases the amount of time required for a player to respond to action, since there's no need to accelerate a bat, racquet, or body as part of the response. Just as it takes time–brief but non-negligible time–for a batter in baseball to accelerate arms and instrument from resting position into striking motion, there is likewise a delay for gestural input between initiation of the action and sufficient data having been generated for the game to unambiguously interpret the action. In some ways, motion control becomes a button that takes longer to press, at the very least removing that key advantage of button-based input. Nintendo's launch title *Wii Sports* works around this difficulty by making the majority of in-game actions either player initiated (bowling, golf), in response to a slow and predictable stimulus (baseball, tennis), or making the inherently lagged input symmetric (boxing).

While part of motion control's conceptual appeal is in the obviousness of input–to swing a racket, a player just performs a swinging motion–one of the advantages of button-based play was that there was no wrong way to perform the game's most fundamental actions, removing any need for operator demonstration. Wii games have responded to this added input complexity through copious use of diagrams, sometimes even multi-frame comics as in *EA Playground*, showing players how to operate the

controllers to perform each task. *Wii Sports* got around this difficulty partly through sequences of captioned diagrams, but also by designing games in which the player at any given time could only perform one fundamental action.

Pre-Wii, digital button controls had changed significantly since the arcade controllers of the late 1980's. By 2006, home console controllers supported many more buttons, directions, and degrees. From pinball's two buttons, arcade games began to have five or six, transitioning to home console controllers with one action button (Atari 2600), to two primary action buttons (NES), to 6 (SNES), and by the time the Wii came to market, X-Box 360 set the standard at 8 primary buttons (two with gradient/analog input), 3 function buttons, two analog sticks, and a directional pad. The Wii remote's complexity for understanding the action to perform still posed a far lower barrier to entry than the out of control input devices becoming standard for other consoles. However it seems reasonable to suspect that this may partly have been because the games fundamentally had to be designed around having at most one-action to perform at a time.

Meanwhile, one of the qualities of button-based play that made it more accessible and ideal for continuous replay, that it largely mitigated fatigue and the effects of normal physical fatigue, got partly lost in the transition to motion controls. When my peers took a break from playing Wii, it was not on account of being tired from genuine exercise as one might optimistically suspect, but instead simply because holding up an arm and moving it in repetitive ways gets tiring very quickly. All change is not progress, and in exchange for the benefit of attracting new players, the Wii lost what has worked so well about button-based play since the introduction of flippers in 1947.

Another advantage to supporting only a single action per context, which somewhat offsets the issue of fatigue, is that nearly any input to the accelerometer can be interpreted broadly as a correct action by the game. This is possible since there's still a layer of calculation and automation between input and result. A rapid shake of the remote in *Wii Sports* delivers a punch as well as any full swing, though requiring less time to

input. A flick of the wrist swings the tennis racket or baseball bat as well as a proper stance and athletic action. Experienced Wii players in the middle of longer play sessions look far less animated, hands on each knee with occasional wrist twitching.

Potentially, the greatest benefit of motion control has been in severely reducing the number of actions available for a player to learn how to perform. Meanwhile in an effort to maximize accessibility, the range of actions accepted as roughly equivalent has largely sidestepped the perceived realism of interaction. In effect, motion control brought games back to 1-2 function experiences, in which the primarily difficulty is once again timing each interaction rather than struggling with complex finger gymnastics to simply perform it. While positioned effectively as something new, some of the core interaction principles are shared with games from older arcade generations.

Lower Risk, Higher Return, Same Infrastructure

When Williams closed its pinball division, it had a rapidly growing slot machine division (*Tilt* 34:50). Slot machines employed similar business and manufacturing infrastructure, but required far less variation between products and typically had a much higher rate of return than their pinball game counterparts. From a strictly business perspective, the company's financial success didn't look as good as it should to Wall Street due to the pinball division diluting the slot machine division's numbers. Commercial game design is a business, and when it no longer made financial sense to allocate people with the design, engineering, sales, and manufacturing experience to produce pinball machines when they could be reassigned to slot machine work to produce higher return on investment, that's what soon happened.

At DICE 2010, Jesse Schell highlighted that Electronic Arts, one of the videogame industry's largest publishers of videogames since the 1980's, had recently laid off 1,500 full-time employees and bought PlayFish, a company that makes formulaic but highly polished social games for the Facebook platform, for $300 million. Companies

across the videogame industry are discovering–or in some cases losing their employees to newer companies that are discovering–that there's potentially a lot less risk (via less product variation), and higher return on producing social games for Facebook than in creating conventional videogames. What changes like one this will mean for the future viability of conventional videogames as a commercial industry is unclear. Hopefully the explosive growth in recent years of mobile, indie, and web games can help partly provide alternative sources of conventional games, however even those are in many cases lower-cost products, perhaps not only holding off the cannibalization but contributing to it.

Looking for parallels with what happened to the pinball industry on account of slot machines, and why, may help shed light on the current market transition. Some of the pinball industry's best years and most successful product runs happened in the 1990's, within a decade of 1999 when, except for Stern Pinball's limited runs, pinball all but disappeared from commercial production in the decade that followed. Where there are differences, as there no doubt are, as I've tried to demonstrate throughout this thesis having something comparable to hold them up against can make it easier to spot subtleties in them.

Closing

Steven Kent opens *The First Quarter* with a quote from Steven Baxter, former producer on CNN Computer Connection: "*You can't say that video games grew out of pinball, but you can assume that video games wouldn't have happened without it. It's like bicycles and automobiles.*" The 12 pages that Kent then dedicated to summarizing the pre-*Pong* amusement industry are largely what inspired this thesis, however the quote from Baxter perhaps deserves a disproportionate amount of credit for influencing my thinking on the connection. The relationship between bicycles and automobiles goes well beyond both having wheels, both being means of transportation, and both being mass-

produced consumer goods: many of the same physical principles and human capabilities are at the heart of why both work. For the relationship between pinball and coin-op videogames, my interest has been in unearthing and documenting some of the shared mechanical principles and human experiences that lead both to work as well as they do.

Pinball and videogames are clearly different games offering different experiences, designed with different affordances, and adapted to player preferences that have roots decades apart. However that same distance, and the commonality that exists between the games in spite of that distance, can call our attention to foundations of play that are more universal than either. As outlined in my section on the Reemergence of Arcade-Style, isolated design strategies and mechanisms can even be borrowed and reintegrated on newer platforms, for newer audiences, as a way to again achieve high accessibility and high replay value with comparatively little content.

The styles of games that are currently the most profitable, at least for the past 5-15 years, have led further away from single-player, twitch reflex, simplified controls, short rounds, and static themes. In their place we are increasingly seeing fierce competition over players that prefer social environments with thousands of players (or matched human-to-human competition), play prioritizing strategic decision-making over real-time performance, more complicated input devices, sessions that last for hours, and cinematic-style storytelling. My hope is that designers and academics alike will remember that there has always been, and will likely always be, an audience whose needs are better served by games that might seem archaic, unfair, or simplistic compared to contemporary practices. After all, there is still a market for bicycles.

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